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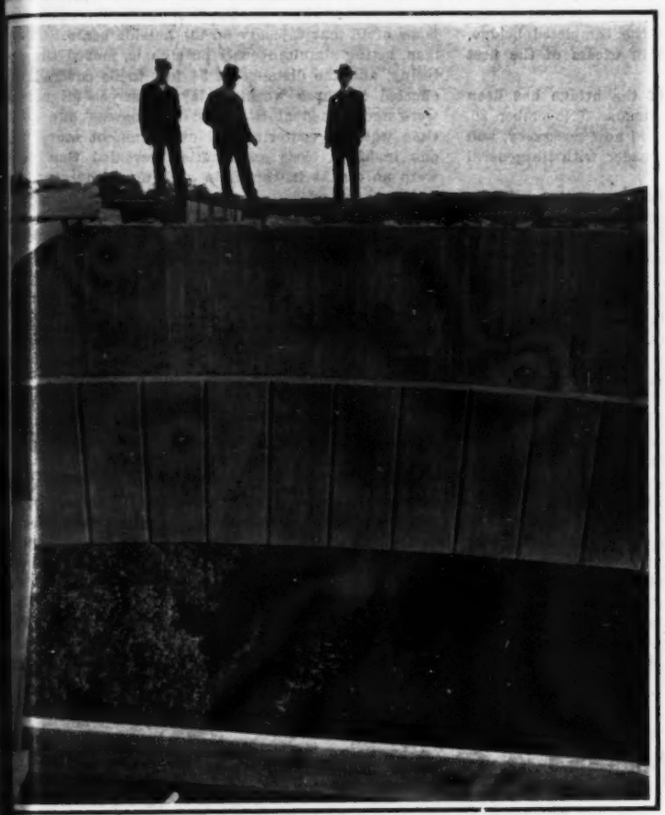
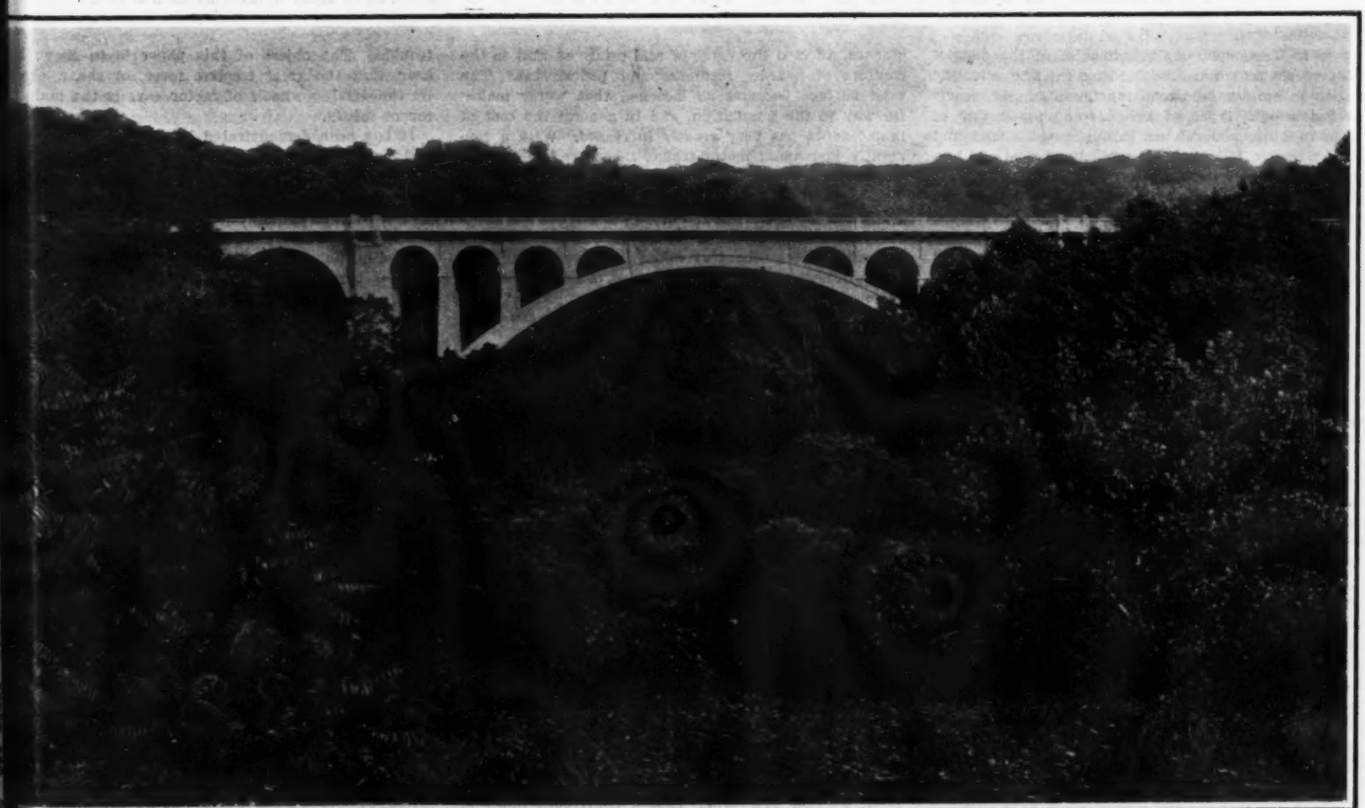


THE CROWN OF THE FIRST ARCH.

LOOKING THROUGH THE TWO BIG ARCHES.



THE MAIN ARCH HAS A CLEAR SPAN OF 233 FEET. THE LARGEST OF THE APPROACH SPANS HAS A CLEAR WIDTH OF 70 FEET; THE FOUR SMALLER SPANS ON EACH SIDE HAVE A CLEAR WIDTH OF 53 FEET EACH.

THE WALNUT LANE BRIDGE AT PHILADELPHIA.

THE WALNUT LANE, PHILADELPHIA, BRIDGE.

A MAJESTIC CONCRETE STRUCTURE.

BY FREDERIC BLOUNT WARREN.

STRETCHING a total distance of 525 feet above Wissahickon Creek, Philadelphia, there has just been opened to the public the largest unreinforced concrete bridge in the world; and pedestrians and traffic, which heretofore have been obliged to make long detours, now have a direct means of communication between Germantown and Roxborough, two districts with a combined population in excess of 100,000.

By the completion of the structure, the road for heavy carting has been shortened five miles, and the carriage road two miles. Besides being a valuable addition to the city's public utilities, the bridge constitutes a splendid monument of architectural beauty and engineering achievement. It embraces a notable arch of majestic proportions—233 feet clear span between the piers—and has attracted the attention of the engineering profession both at home and abroad, because of its great size and height and the novelty of its method of construction.

It has been the policy of the Engineering Department of Philadelphia to provide the city with bridges which satisfy the æsthetic eye as well as to conform with engineering and economic practicability. Particularly has this been so in Fairmount Park. The Wissahickon at the point where the bridge spans it is 90 feet wide and runs through a heavily wooded gorge, whose banks slope steeply back to an elevation 140 feet higher than the creek level. The bridge itself is 147 feet higher than the creek level. Its surroundings are wild, like many outlying portions of the park.

The whole structure is of concrete with a surface finish resembling stone in color, texture, and wearing qualities. Such steel as was used is deeply embedded in the concrete, no metal is anywhere exposed to view or to the elements, and in nearly all construction essentials the bridge is without reinforcement.

In every detail, from the day the plans were first laid down until obstacles were removed at either end that vehicles might cross it, the bridge was built by the city of Philadelphia under the supervision of municipal officials.

The outsider and a certain element of native Philadelphians are prone to consider every piece of public work so much "fat," to be fried out in the pans of the big contracting firms; and two years ago, when the bridge construction began, these critics were as skeptical as ever about the possibility of the city attempting to do a piece of its own work without outside assistance. The best evidence of the care expended on the work is shown by the cost of the completed bridge, $259,000, which is only $6,000 in excess of the first estimate of cost.

As a complete description of the bridge has been published in the SCIENTIFIC AMERICAN (November 30, 1907) only an abridged account is now necessary, and that merely to familiarize the reader with its general outlines.

The general plan of the structure is that of twin supporting arch ribs floored across on top, and this scheme is carried out throughout the five approach arches as well as the main arch. The plan insures economy as well as lightness. Over each main arch rib the floor is carried on eight pairs of spandrel or relieving arches, which support the four longitudinal walls upon which the floor rests. The whole is hollow underneath up to the floor, and consequently no earth filling was required. This effected a great saving in weight.

The five approach spans, while small in comparison with the main arch, are of a size that not many years ago would have been considered large. They are each 53 feet clear between the piers, and those next to the main span are about 70 feet clear above the ground.

One of the most interesting constructive phases of the work was the erection of the arches on a falsework centering, which was first erected under one of the parallel arch rings and, after that ring had been completed, moved over in its entirety to its position under the other ring. This centering consisted of six stories of timber resting on one layer of structural steel, which in turn rested on concrete piers founded in the creek bottom. The falsework was 147 feet high, 232 feet long, and 50 feet wide at the bottom. Its total weight was about 900 tons. On the top of the concrete piers was a plate of cast steel, being really a track upon which were set cast steel rollers bearing the weight of the centering. Fifteen ball-bearing ratchet jacks of 35 tons capacity were used for moving the middle bents, where the heaviest loads were, and nine jacks of 15 tons capacity on the outside bents. Thirty men, acting simultaneously on signals, moved the centering, and the distance of 34 feet to be covered was effected in three working days. Correct alignment were maintained at each foot of progress, and at no time was the centering out of alignment more than one inch. A close examination revealed that there were no cracks in the main arch after the centering had been moved.

This falsework was no small affair. It used 360,000 feet of timber, 130 tons of structural steel, and 20 tons of three-quarter inch bolts, and 2 tons of washers for the bolts.

Nearly 300 men were employed for two years to build this bridge, and 19,000 yards of concrete, weighing more than 40,000 tons, was used. While the bridge's cost is greatly in excess of what it would have been for a similar structure of steel, the difference in initial cost is virtually equalized by the fact that there will be almost no maintenance expenses on the bridge while a steel bridge must be frequently painted and kept in repair.

This bridge has attracted the attention of engineers throughout the world. Sir Maurice Fitzmaurice, the chief engineer of London, who inspected it recently, declared it was worth a trip across the ocean to see.

The parapets along the 8-foot sidewalks are of concrete balustrades of classic design. The driveway is 40 feet wide.

The bridge was designed by the Department of Public Works, Bureau of Surveys, under the direction of George S. Webster, chief engineer, and Henry H. Quimby, his assistant.

EFFECT OF MOTORS ON MACADAM ROADS.

HOW CARS OUGHT TO BE DESIGNED TO PRESERVE ROADS.

IT is to Tresauget, engineer-in-chief of the district of Limoges, that we are indebted for the first scientific treatise on broken-stone road construction. He clearly specified several types of broken-stone roads, one of which, in quite general use throughout England and America to-day, is known as the Telford road. It is a matter of interest that, while roads of the Tresauget type are in extensive use throughout England and America, they are rarely seen in France, the macadam type having almost entirely superseded it. Tresauget's report to the Council of Bridges and Roads, written in 1775, on road maintenance is, in my opinion, the best ever written on the subject. Following Tresauget, MacAdam made his splendid contribution. Since the time of these great engineers many improvements and modifications have been made in road building, the most important of which have been largely brought about by time and labor-saving machinery.

It is not my purpose to consider the history of road building, and I have only alluded to it for the purpose of showing that the broken-stone road of to-day has been of slow development. Although the methods of construction vary somewhat in different countries and different localities, the main object sought has always been the same—to withstand the wear of iron-tired horse vehicles at a reasonable cost. Until the last decade these conditions have been successfully met, and the broken-stone road was all that could be desired. Under modern motor traffic, however, the conditions have changed. Roads which formerly withstood the wear of horse vehicles are now quickly denuded of the fine binding material and become loose and disintegrated. On the principally traveled roads the great clouds of dust raised by rapidly moving motor vehicles are not only a great waste of the material of which the road is composed, but this dust is carried by the wind and disseminated over adjacent property to such an extent that it has, in many instances, affected the value of real estate as well as the comfort of near-by residents and pedestrians. The road surface becomes so loosened that water makes its way to the foundation, and in general the cost of maintenance has very greatly increased. With a constantly increasing motor traffic, these are, briefly, the conditions we find to-day, and which have to be met. The problem is such a serious one that it has called forth the best efforts of highway engineers in every civilized country. By the proper use of bituminous materials the mechanical difficulties have in a large measure been overcome, but the cost of such treatment is so great that it is hard to believe, at present, that such methods can ever be generally used on the many thousand miles of rural highways affected.

As already stated, the broken-stone road has been developed to withstand the wear of iron-tired horse vehicles and has met successfully the demands of suburban and rural traffic until the advent of the motor vehicle. When in its highest state of perfection, the rock from which such a road is made is so suited to the volume and character of traffic which passes over it that the amount of dust worn off is only sufficient to replace that removed by wind and rain. The dust remaining should be just enough to bond the surface stones thoroughly, forming a smooth, impervious shell. A road of this character wears uniformly under the traffic for which it was designed and when properly maintained always presents an even surface.

When such a road is subjected to continuous fast motor traffic, entirely new conditions are brought about. Since the advent of this new traffic its effect on the road has been the subject of much study, by both highway and mechanical engineers, and many highly interesting and ingenious theories have been advanced to account for the injury to roads derived from it. While the slipping of the tire, skidding, shape of car body, suction and other causes contribute more or less to the injury of the road surface, I think it is quite generally believed that the suction of the pneumatic tire on the surface is the main cause of the trouble. The object of this paper is to show, however, that the great tractive force, or shear, exerted by the driving wheels of motor cars is the main factor of injury.

It has been demonstrated by connecting both front and rear wheels of motor cars with separate speedometers that there is a considerable amount of slipping of the driving wheels on the road surface, even on account of the numerous irregularities on the average road surface, this is what should be expected. This slip, due to the decrease in the bearing surface of the tire, undoubtedly increases the amount of finely divided material of the road surface thrown into the air. The increased amount of damage done on this account will be in proportion to the irregularities in the road and the speed of the car. While this is an important factor, its effect is greatly reduced if the road has a smooth surface.

The effect of skidding is only observable on roads that are subjected to a considerable volume of fast motor traffic, and only then on curves. The result of this is to shift the crown of the road tangentially to the gutter. While very annoying to those having the maintenance of such roads, it is not one of the serious or costly causes of injury, as it is generally confined to rather sharp curves.

It is my belief that too much stress has been laid upon the effect of the car body and its shape in the moving dust from the road surface. After a number of experiments and observations, I am now convinced that little or no dust is removed from the road surface by this means, except on very dusty roads. The dust lifted by the wheels, however, is greatly accelerated by the action of the car body and the air currents set up in its rear, which has much to do with the dissemination of dust. This is one of the important factors to be considered, as much of the dust lifted by the wheels would not be carried from the road but for the air currents developed by the car body, and these, of course, are much affected by its shape.

*An address before the National Good Roads Convention at Buffalo by Logan Waller Page, Director, Office of Public Roads.

Probably no single factor has been considered of as much importance as the so-called suction of the pneumatic tire. Some writers have even gone so far as to maintain that a slight vacuum is created in the rear of each tire, which is sufficient to lift the finer particles of the road surface in the air. In my opinion, entirely too much importance has been given to this phenomenon, for if it exists at all, its effect is probably so slight that it can be considered a negligible quantity, and I shall endeavor later on to give my reasons for this view.

Beyond a doubt, the most injurious action of motor traffic is the great tractive, or shearing, force exerted by the driving wheels of these cars. The fine dust which ordinarily acts as a cementing agent to the road surface is thrown into the air to be carried off by the wind, or that remaining on the road is so loosened that it is easily washed into the gutters by rain. The pneumatic rubber tire wears off from the broken stone of the road little or no dust to replace that thus removed, and the result is that the stones become loose and rounded, giving the greatest resistance to traction and allowing water to make its way freely to the foundation of the road.

For the purpose of studying this phenomenon I recently conducted a series of tests with motor cars of various shapes and sizes, from the 4,000-pound limousine to the small runabout. These cars were run at various rates of speed, and their effect studied on a section of average broken-stone road. The most interesting result was obtained with a 60-horse-power car stripped for racing. The wheels of this car were 36 inches in diameter, with 4-inch front tires and 4½-inch rear tires. The weight of the car with driver and mechanism was 2,800 pounds. This car was driven over a level section of broken-stone road at speeds varying from 5 to 60 miles an hour. The road used was a section of a government road which had been resurfaced two years previous to the test and was in very good condition. Up to 15 miles an hour little or no effect was produced on the road, and even at 20 miles an hour it was judged by those present that no serious damage was done. From 20 miles an hour on, however, the effect was markedly noticeable with each increase in speed. At a point on the road designated for the proper speeds, photographers with the necessary high-speed cameras were stationed for the purpose of taking photographs from different points of view of the effect produced. All these photographs, in my opinion, illustrate the action of the wheels very clearly. They show the car traveling at from 5 to 60 miles an hour.

To sum the matter up briefly, the pneumatic tire, or any type of tire which propels a vehicle, must have sufficient tractive resistance to overcome the load of the vehicle. This, of necessity, must cause a shear on the road surface, which varies with the weight and speed of the vehicle. The broken-stone road surface has little power to resist a shearing stress, consequently the fine material of which it is composed is thrown into the air. Once lifted from the road, this fine material is subject to the effect of air currents generated by the car body, and subsequently by the wind. In this manner large quantities of the material of which the road is composed are carried from the road and must eventually be replaced or the road will rapidly deteriorate. This action may be greatly accelerated by other causes, but in the main it is sufficient to account for the observed results. Apart from the dust carried from the road in this manner, this shearing force of the motor car has a decided disintegrating effect on the surface of the road.

ELECTRIC FURNACES IN GERMANY.

WHAT IT COSTS TO REDUCE ORES ELECTRICALLY.

In transmitting the following report on electric furnaces in German steel works, Consul Thomas H. Norton, of Chemnitz, says that apparently it is only a question of time until the crucible processes will be entirely superseded.

Hitherto electric furnaces in Germany have been used chiefly for the treatment of small quantities, but now the leading works are beginning to employ them on an extensive scale for handling large quantities of metal. At the close of 1907 one of the most important steel works in the empire engaged in the production of cast steel for gears, as well as of the softer varieties of malleable cast steel for automobile construction and for minor machine parts, decided to replace its battery of crucible furnaces by a large electric fusion furnace. The main cause for the change was the desire to lessen the cost of fusion, while not lowering the quality of the steel, but, on the contrary, improving it, if possible.

The old equipment consisted of 32 furnaces, each containing six crucibles, with a capacity of 77 pounds. They are replaced by a single electric furnace of 250 horse-power, capable of holding a charge of a metric ton (2,205 pounds). A duplicate furnace is likewise installed and kept as a reserve for emergencies.

Electricity is supplied from the large works of a company near Cologne, which furnishes a three-phase current of 5,200 volts to quite a large territory near the Rhine for both power and illumination. Alterations in the current intensity are so slight that connection is made directly, without the interposition of a regulator, between the furnace and the transforming station. At the latter a three-phase rotatory current, reduced to a tension of 110 volts, is supplied.

PRODUCTION OF CAST STEEL.

The production of cast steel in this furnace has been carried on since the beginning of 1908 without interruption, and with such a degree of success that the results are well worth the attention of American steel manufacturers. Details of the cost and process generally are herewith reproduced in some fullness, on account of the far-reaching importance of this revolution in the central feature of one of the leading industries of the United States.

The main product of the furnace has been cast steel, containing about 0.06 per cent phosphorus, 0.03 per cent sulphur, and from 0.08 to 0.18 per cent carbon. Occasionally charges of tool steel have been cast, containing from 0.7 to 1.3 per cent of carbon, with and without the addition of nickel, chromium, or tungsten. The material employed is ordinarily slugs, cuttings, turnings, and other waste of wrought iron, costing from $14.28 to $15.47 per metric ton (2,205 pounds) $12.96 to $14.04 per short ton. A fusion, including the reheating, lasts about five hours and involves a consumption of about 900 kilowatt hours for 1 metric ton of cast steel. The entire charge of 1 ton is poured at once. When the furnace is kept in continual use the magnesite lining lasts for about 70 operations, i. e., twenty to twenty-five days. A stoppage of five days is required for each renewal, but during this period the reserve furnace is employed.

The cost of the electric current is exceedingly low, on account of the large amounts consumed. It amounts to 4½ pfennigs (1.071 cents) per kilowatt hour, so that the expense for a single operation is about 40 marks or $8.64 per short ton.

The total cost of cast steel, thus produced, per metric ton, is as follows:

For—	Cost.
Amortization of cost of plant	$1.19
Raw materials, including additions, chromium, etc.	16.66
Electric current, including heating during intervals	10.71
Renewal of magnesite lining	2.85
Labor	2.38
Electrodes	.60
Water for cooling purposes	.12
Total	$34.51

This amounts to $31.32 per short ton, and is materially less than the cost of crucible steel.

ADVANTAGES OF THE ELECTRIC PROCESS.

The manufacturing firm notes in addition these advantages in the electric process, as compared with the old method: (1) Cheaper raw material can be employed in the place of the more expensive Swedish iron formerly required; (2) in fusing quantities of a ton at a time it is possible to produce homogeneous masses of a distinct, well-defined grade; (3) the molten steel leaves the furnace of a much higher temperature than when prepared in crucibles, is therefore in a more liquid condition, and is easily transferred to ordinary ladles, preparatory to pouring into the molds of small castings.

These electric furnaces are arranged on the Stassano system, and are supplied in all sizes, for charges varying from 400 pounds to 10 tons, and are adapted for the fusion of metals of every kind. The construction is shown by the designs forwarded [and filed for inspection at the Bureau of Manufactures].

The furnace for cast steel is constructed of iron plates, heavily lined with magnesite bricks. Carbon electrodes enter by three openings on the sides, and are so adjusted as to terminate slightly above the surface of the molten metal, whereby the heat of the arc is absorbed almost entirely by the contents of the furnace, and but a small portion is radiated upward, to be reflected from the concave dome.

MIXING AND FUSION—OTHER USES.

A thorough mixing of the component parts of a charge is effected by mounting the furnace on an axis, slightly inclined from the vertical. A steady revolution about this axis is maintained through a cogged connection, with a dynamo of 5 horse-power, the edge of the furnace resting on ball bearings. This rotation causes the lower layers to gradually rise to the top of the molten mass, and brings about a thoroughly uniform mixing. The electrode supports are inclosed in cylinders and surrounded by a current of cold water. These supports are in rigid connection with hydraulic cylinders, by means of which the movements of the electrodes are under perfect control.

A fusion requires 3½ hours to be complete; a further period of 1½ hours is requisite for the removal in succession of phosphorus and sulphur, and the final deoxidation of the contents of the furnace. No interruption occurs in either the current of electricity, or in the supply of water for cooling the electrode supports, while the furnace is in rotation. Special devices have been provided for both purposes.

The services of three workmen are required to conduct an electrical furnace, change electrodes, transport the raw materials, etc. Furnaces of the type in question are now being introduced in Germany for the treatment of other metals and alloys, and it is apparently only a question of time before the crucible processes hitherto in such general use will be completely superseded.

BLAU GAS: A NEW GAS FOR ILLUMINATING, HEATING, AND POWER PURPOSES.

It has been customary in the past, in the case of the preparation of compressed gases for illuminating purposes, to eliminate from the gas mixture those gases high in carbon which liquefy under pressure. These gases, however, are the most valuable for heating and lighting purposes, and Blau set himself the problem of producing a liquid which should be a mixture of several easily volatile compounds, such as the hydrocarbons—propane, butane, isobutane, the pentanes, propylene, butylene, etc. These gases are readily compressed into liquids, and in the latter state they will dissolve large quantities of the permanent gases, hydrogen, methane, etc. In order to obtain such a gas mixture which, after liquefaction, evolves the permanent and non-permanent gases in a constant and definite proportion, Blau carries on the distillation of the coal, etc., at a temperature much lower than is usual (600 to 700 deg. C.). The whole product of the distillation is then put through the usual processes of purification and is finally submitted to high pressure. Under this pressure, the heavier gases liquefy, and at the same time become saturated with the permanent gases. Any excess of the latter passes off for use in any of the ordinary ways, while the pressure solution is filled into steel cylinders for transport. These cylinders contain from ½ kilogramme to 25 kilogrammes; a medium-sized cylinder measures 3 feet high by 5 or 6 inches in diameter, and contains 10 kilogrammes or 22 liters of the liquefied gases. Such a cylinder at 15 cents per kilogramme would cost $1.50, and would supply a 50-candle-power incandescent burner for 480 hours, or four months, at the rate of four hours per day. A kerosene burner would require about 120 liters or 32 gallons. The specific gravity of the liquefied gases is 0.59 (water 1.00) while that of the gas when liberated is 1.105 (air 1.00). The thermal equivalent of the gas is 12,318 kilogramme-calories per kilogramme. For incandescent lighting it is very important to have a gas of high calorific value, since the concentration of the heat produces a high temperature in the mantle and increased illuminating power. The intensity of the light produced by the new gas is as follows:

Consumption.	Intensity.
0.63 cubic feet per hour.	50 Hefner candles.
1.07 cubic feet per hour.	100 Hefner candles.
3.63 cubic feet per hour.	500 Hefner candles.

Following the success of the Valtellina line and the Milan-Porto Ceresio line, a number of other Italian railways are being electrified. The total number of miles now being electrified is 179, this mileage being divided among nine different lines. It is expected that they will all be completed in 1911.

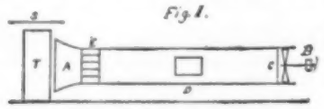
THE LIFT AND DRIFT OF ARCHED SURFACES.*

HOW THEY BEHAVE IN A UNIFORM CURRENT OF AIR.

BY MATTHEW BACON SELLERS.

THIS work was commenced in 1903, and was the subject of a short paper read at the St. Louis Aeronautical Congress of 1904. Since then it has been continued intermittently, and is not yet completed; though I feel that enough has been done to justify the publication of the results thus far obtained. The object of these experiments is to determine the relative efficiency of various arched surfaces, as to their supporting power, and resistance to forward motion, when inclined at various angles to the impinging air. It might be thought feasible to determine the normal pressure at the required angles of incidence, and from this to compute the horizontal and vertical components, as has been done in the case of plane surfaces. But it seemed doubtful whether this could be done with certainty, for reasons that will appear later. The lift and drift were therefore separately determined. To obtain a uniform air current of known velocity a wind tunnel was used. My first tunnel was 3 feet in diameter. The one which I am now using is 30 inches in diameter and about 20 feet long, octagonal in cross section and placed horizontally. The air current in this tunnel is produced by a six-bladed suction fan, placed at the end *B*, Fig. 1; the current flowing from *A* to *B*.

Fig. 1.



In order to make the air current horizontal and uniform, a funnel-shaped end was employed at *A*, horizontal and vertical guides at *E* (see Fig. 2), and a wire screen at *C*. It was also found necessary to place a horizontal shield at *S*, and a vertical partition at *T*. Eventually the current was made so nearly horizontal that the tests applied showed no inclination.

About midway of the tube is the device for supporting the surfaces to be tested; and there is a glazed sliding window in the side of the tube at *D*.

At first a 1-horse-power electric motor, taking current from storage batteries, was used to drive the fan. In 1907 I employed a steam engine having a pressure-regulating valve placed in the steam supply pipe; and, as an auxiliary to this, hand regulation at the engine.

It is evident that the steam pressure will vary approximately as the square of the velocity of the fan, provided that other conditions are kept constant; therefore a control of the steam pressure should give a more uniform velocity than a direct control of the velocity, provided the percentage of variation is the same in both cases. When the valve is working properly, the steam pressure varies about one per cent, but this is not always the case, and then hand regulation is necessary. The balance for measuring the "lift" is shown in Fig. 3. The beam *B* is pivoted at *P*. The pendant *C* is pivoted at *Q*, and is held in vertical position by the piece *E*, pivoted to it at *R*, and at *S* to the inverted post *A*. The pendant *C* carries at its lower end the support *G*, with its graduated arc *D*. The surface *H*, to be tested, is attached to the support by means of the screw eye *G*. The pointer is brought to the zero mark *F* in still air, by means of counterweights *x* and *y*, and, when the air current is flowing the lift is balanced by the weight *J* and the sliding weight *W*.

The drift balance (Fig. 4) comprises the beam *B*, pivoted at *P* and rigidly connected to the vertical arm *A*, passing through the top of the tube at *T*. To this at *Q* is pivoted the piece *C*, supported at its other end by the pendant *E*, pivoted at *R* and *S*. The piece *C* carries the support *D* with its graduated arc; and the bodies tested are attached by means of the screw eye *G*. The horizontal pressure of the wind, acting in the direction of the arrow, is balanced by adding weight at *H* and adjusting the sliding weight *W*. As *A* and *E* are vertical when balance is obtained, their difference in length does not introduce appreciable error. The pivots are polished steel in brass bearings, and the balance is sensitive to 0.2 gramme when loaded. These balances can be assembled in a few minutes, and each in its turn occupies the same position in the tunnel. It is evident that if the *velocity* of the wind were kept constant throughout the series of experiments, the pressure on a unit surface would vary with the temperature and barometric pressure. But as the primary object of this work is to determine the relative efficiency of the various shapes tested, it was determined to operate with a wind velocity capable of exerting the same unit dynamic pressure throughout the series of experiments; thus the corrections for atmospheric conditions were rendered unnecessary. It was therefore important to devise an instrument capable of indicating the desired air pressure, and sufficiently sensitive to show a very slight departure from that pressure. For the purpose I constructed what might be called a differential gage, shown in diagram in Figs. 5 and 6. A triangular airtight box *A* is divided horizontally by a partition *B*, in which is a circular hole covered by the diaphragm *D* of thin sheet rubber, on which rests the disk *C*; and below, fastened to *C*, the disk *E*. The disk *C* carries a bearing, and the pointer *F* is pivoted to this at *P* and to the wall of the box at *P'*. The tube *x*, passing through the top of the tunnel and facing the air current, communicates with the lower chamber of the gage; and the tube *y*, facing as shown, connects with the upper chamber. The difference in pressure causes the diaphragm to rise, which is indicated by the pointer *F* on the scale *G*. A pin *P* carries lead disks, enough being added to bring the pointer to the center of the scale, when the desired current is flowing.

The ball-gage, Fig. 7, is used to supplement the differential gage. A box *A*, with glass front, is fastened to the top of the tunnel. The bearing *B* is fixed to the side of the box, and to it the arm *C*, rigidly connected to the pointer *D*, is pivoted. This arm *C* passes through the top of the tunnel at *F* and has a ball *E* of thin glass at its lower end. The wind pressure, acting in the direction of the arrow, would cause the pointer to rise, but is balanced by the weight *w*, clamped in such a position that the desired pressure causes it to stand about the center of the scale. A dash pot *G* acts as a damper. The ball and arm are very light, the device is sensitive, and responds at once to a change of pressure; whereas the differential gage is dead beat, and responds slowly to a change of pressure. It is more sensitive than the ball gage, showing clearly a ½ per cent change of pressure. The wind velocity was determined with a Biram anemometer when desired, and it was found convenient to adopt a dynamic pressure of eighty grammes on a 6x6 inch square of sheet iron, exposed normal to the air current, and this pressure was found to correspond to a wind velocity of about 1,400 feet per minute, depending of course on atmospheric conditions. The metric weights were used because convenient, but dimensions were measured in feet and inches. The chief source of error was a continued oscillation in the air pressure and velocity, as indicated by the pointers of the instruments moving slowly up and down between constantly varying limits. This made it difficult to determine when proper balance was obtained. However, as each of the results here given represents the weighted mean of a number of trials, the error should not exceed from 2 to 6 per cent, being greater for the smaller values. It was found that large surfaces showed a greater unit pressure than small ones when normal to the current, and this was attributed chiefly to interference or blocking of the tube. It seemed, however, that a small part of this difference might be due to the size of the surface, independent of interference. In the tables the percentage given is the ratio of the lift or drift to the standard unit pressure on a 6x6 inch normal plane expressed in hundredths. This pressure was 80 grammes, or 320 grammes per square foot. Part of this pressure is due to interference. In the case of the surfaces tested, the interference increases with the angle of inclination to the air current, being very slight for small angles and considerable for large ones, hence adopting the unit pressure on a 6x6 inch plane, in computing the percentages, will give somewhat lower values for the small angles, and higher values for the larger angles, than would obtain if there were no interference. This will not materially affect the comparison of the surfaces, and should give good working values for angles at which aeroplanes are used, viz., from 0 to 20 deg. I decided to employ chiefly surfaces of the uniform size of 6 inches by 12 inches; because with large surfaces, small differences in pressure would be more apparent; and though their size would introduce some error through interference, this would be practically the same for each, and so would not affect their comparison.

Fig. 2.

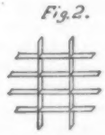


Fig. 3.

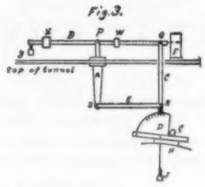
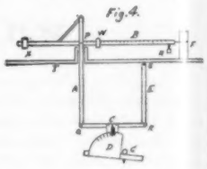


Fig. 4.



However, to see what effect size would have on the results, a 4¼x8½-inch surface was compared with a 6x12-inch surface having the same curvature. Owing to the difficulty in getting a perfectly flat thin metal plate, a 4¼x8½ flat thin glass plate was used to determine the pressures on a plane.

All surfaces were exposed with the long edge facing the wind. For brevity and convenience the various surfaces used will hereafter be called shapes. The amount or depth of curvature of a shape is expressed by the greatest distance of the curve from its chord, divided into the length of the curve; e. g., a shape 6 inches fore and aft and curved to the depth of ½ inch would be 1 in 12. Table 1 gives the lift of three

TABLE I. LIFT.

Inclination in degrees.	Plane 4¼ x 8½ in.		Arched 1:12—4¼ x 8½ ins.		Arched 1:12—6 x 12 in.	
	Corrected mean lift in grms.	Per cent N=80.3	Corrected mean lift in grms.	Per cent N=80.3	Corrected mean lift in grms.	Per cent N=100
0	0	0	22	27.4	44	27.5
5	15	18.7	41	51.6	83	51.9
10	30	37.4	57	70.9	112	70
15	44	55	68	84.7	132	82.5
20	53.2	66.3	77.5	96.5	152	95
25	53.2	66.3	83.3	103.7	164	102.5
30	50.5	62.9	77.5	96.5	152	95
35	49.2	61.2	64	79.7	128	80
40	48.2	60	60	74.7	121	75.6
45	47.5	59.1	56.5	70.4	116	72.5
50	46	57.3	53	66	110	68.8
60	39	48.6	44	54.8	97	60.6
70	28.5	35.5	31	38.6	70½	44
80	14.5	18	16	19.9	36	22.5
90	0	0	0	0	0	0

Fig. 7.

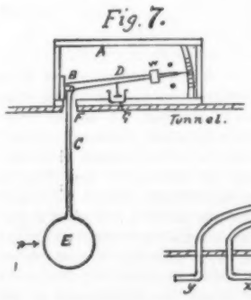


Fig. 5.

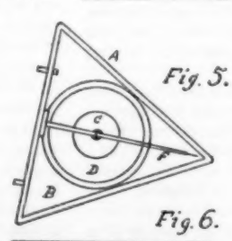


Fig. 6.

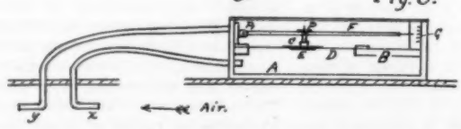
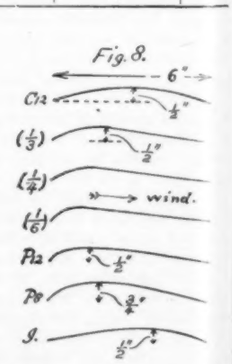


Fig. 8.

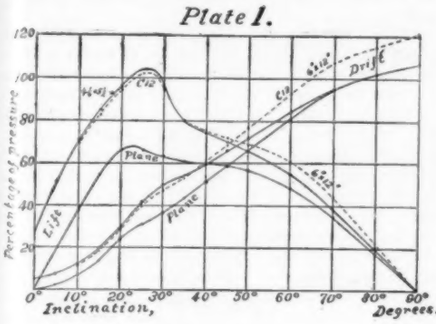


shapes, viz., a plane 4¼ x 8½, a 4¼ x 8½ shape; arc of a circle in profile; curvature 1 in 12; and a similar shape, but 6 x 12 inches in size. The angle, column 1, is that made by the plane or by the chord of the arc with the direction of the wind. Column 2 gives the corrected mean lift in grammes, the correction being for lift on portions of the balance. The third column gives the percentage of lift taking *N* at 320 grammes per square foot.

* Copyright 1908 by Matthew Bacon Sellers.

Table 2 gives the drift. The correction here was for the resistance offered by the drift balance, which was experimentally determined for each angle; besides this, the skin friction and head resistance proper of the shape (i. e., that due to the thickness of the edge or to any support, etc.) were deducted. Plate I shows graphically the lift and drift of these shapes; the abscissas being the angles of inclination, and the ordinates the percentage of lift or drift. It will be noted that the lift and drift of the 6x12-inch shape nearly coincide with those of the 4¼x8½-inch shape for angles below 45 deg. If there were any considerable interference, the larger surface would give higher values; but here they are slightly lower, probably due to a slight unnoticed difference in curvature, and we may

Plate I.



conclude that for small angles of inclination, the 6x12-inch shape gives practically as accurate values as a smaller shape would give. The values above 45 deg. are of course of little use in aviation, but are shown here, as they may prove interesting; they are of course affected by interference. It will be noted that the drift of the plane near 90 deg. is the same as that of the smaller arched shape; in fact, I found this to be the case with several arched surfaces tried, but a

TABLE II. DRIFT.

Inclination in degrees.	Plane 4¼ x 8½ in.		Arched 1 in 12—4¼ x 8½ ins.		Arched 1 in 12—6 x 12 ins.	
	Corrected mean drift in grms.	Per cent N=80.3	Corrected mean drift in grms.	Per cent N=80.3	Corrected mean drift in grms.	Per cent N=160
0	0	0	3.7	4.6	7.5	4.7
5	1.4	1.7	5.5	6.8	11	6.9
10	5.6	7	9.7	12.1	18.2	11.4
15	11.5	14.3	15.5	19.3	29	18.1
20	19.4	24.1	23.5	29.3	45	28.1
25	25.2	31.4	33.7	42	64.7	40.4
30	29.2	36.4	40	49.8	76	47.5
35	34.7	43.2	42.5	52.9	84.5	52.8
40	40.8	50.8	48	59.8	97.5	60.9
45	47.2	58.8	53.2	66.3	110.5	69
50	53	66	58	72.2	124	77.5
60	65.5	81.6	67.5	84.1	152	95
70	75.2	94.9	76	94.6	173	108.1
80	82	102.1	82	102.1	185	115.6
90	86	107	86	107.1	194	121.3

TABLE III. LIFT.

6 in. x 12 in.					Curvature=arc of circle.				
Corrected lift in grammes.					Per cent—Lift—N=160				
Angle deg.	C 24 1 in 24	C 12 1 in 12	C 8 1 in 8	C 6 1 in 6	Angle deg.	C 24	C 12	C 8	C 6
0	28	44	45	20	0	17.5	27.5	28.1	12.5
5	60	88	96	65	5	37.5	51.9	60	40.6
10	94	112	135	124	10	58.7	70	84.4	77.5
15	122	136	152	160	15	76.2	85.1	96	100
20	139	152	168	171.5	20	86.9	95	105	107 2
25	139	164	180	182	25	86 9	102.5	112.5	113.7
30	125	152	180	183.5	30	78.1	95	112.5	114.7
35	117	128	151	177.5	35	73 1	80	94.4	111
40	114	121	131.5	141	40	71 2	75.6	82 2	88.1
45	111	116	125	126.5	45	69.4	72 5	78 1	79

tion at which maximum lift occurs is about 22 deg. for the plane and increases with the degree of curvature.

The maximum lift is greater for surfaces of greater curvature; and with the standard of comparison here used in computing the percentage, runs well above 100 per cent. Owing to the errors introduced by interference, it cannot be determined from the data at hand just when and how much the maximum lift of a shape

TABLE IV. DRIFT.

6 in. x 12 in.					Curvature arc of circle.				
Corrected drift in grms.					Per cent of drift—N=160				
Angle deg.	C 24	C 12	C 8	C 6	Angle deg.	C 24	C 12	C 8	C 6
0	2.7	7.5	13.5	16.7	0	1.7	4.7	8.4	10.4
5	5.7	11	20	24	5	3.6	6.9	12.5	15
10	14.5	18.2	28.5	33.6	10	9.1	11.4	17.8	21
15	28	29	37	45	15	17.5	18.1	23.1	28.1
20	46	45	48.5	54	20	28.8	28.1	30.3	33.7
25	61.7	64.7	65.7	66.7	25	38.6	40.4	41.1	41.7
30	69.5	76	85	82.5	30	43.4	47.5	53.1	51.6
35	80	84.5	93.5	99.5	35	50	52.8	58.4	62.2
40	93	97.5	101	107	40	58.1	60.9	63.1	66 9
45	106	110.5	115	120	45	66.2	69	71.9	75

is greater than its drift at 90 deg.; but it may be inferred that the maximum lift is greater than the drift at 90 deg. for curvatures greater than 1 in 12. Beyond the peak in the plotted curves the lift diminishes rapidly; also there is a hump in each of the curves, that in the C6 occurring at about 15 deg. It was at first thought that these irregularities were in part due to experimental error; but beyond the possi-

TABLE V. CUPPED DISK.

Angle in deg.	Lift in grms.	Drift in grms.	Lift P. C. N=63	Drift P. C. N=63
0	12	5 5	19	8.7
5	25	7	39.7	11.1
10	37	10	58.7	15 9
15	48	14.8	76.2	23 5
20	57	21.7	90.5	34 4
25	66	28.5	104.8	45.2
30	73.5	38	116.7	60.3
35	77.5	48	123	79.5
40	66	54	104.8	85.7
45	55	55	87.3	87.3

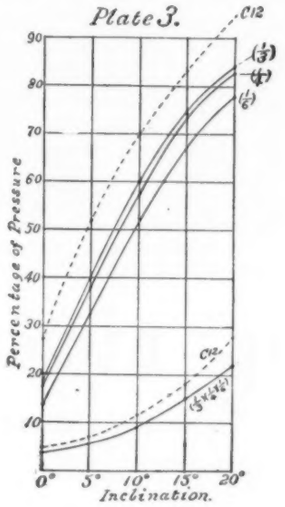
A shape advocated by some experimenters has its front portion more or less sharply curved, and its rear portion flat. Table 6 gives the results of tests of three shapes of this character.

TABLE VI. FRONT CURVED.

Lift.							Drift.	
Grms.			Per cent; N=160			All.		
Angle deg.	(⅓)	(¼)	(⅙)	(⅓)	(¼)	(⅙)	Grms.	P. C.
0	30	28	22	18.8	17.5	13.8	6	3.8
5	64	61	52	40	38.1	32 5	9.8	5.8
10	96	92	84	60	57.5	52.5	14.6	9.1
15	119	118	102	74.4	73.7	63.8	24	15
20	134	132	125	84	82.5	78	35	22

In profile these shapes have a circular arc for 1/3, 1/4, and 1/6 of their width respectively, the remain-

Plate 3.



ing portion being flat, as shown in Fig. 8 (which shows also the other shapes). The drift is given as the same for all; but it was slightly greater for the

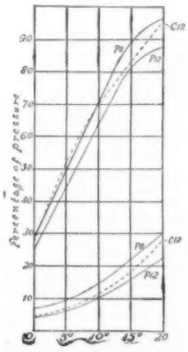
TABLE VII. PARABOLIC SHAPES.

Lift in grms.			Lift P. C.		Drift in grms.		Drift P. C.	
Angle deg.	P 12	P 8	P 12	P 8	P 12	P 8	P 12	P 8
0	40	46	25	28.8	6.7	11.2	4.2	7
5	71	79	44.4	49.4	10.2	15.2	6.4	9.5
10	102	118	63.7	70.6	16.7	23	10.4	14.4
15	130	142	81.2	88.8	25.5	35	16	22
20	140	154	87 5	96.2	36	48	22.5	30

1/6 shape than for the others. In Plate 3 these values are plotted, as also a C12 shape for comparison. Evidently the shape called 1/3 is the most efficient of the three.

Table 7 gives the values for two parabolic shapes. Each is the half vertex of a parabola, P12 being ½

Plate 4.



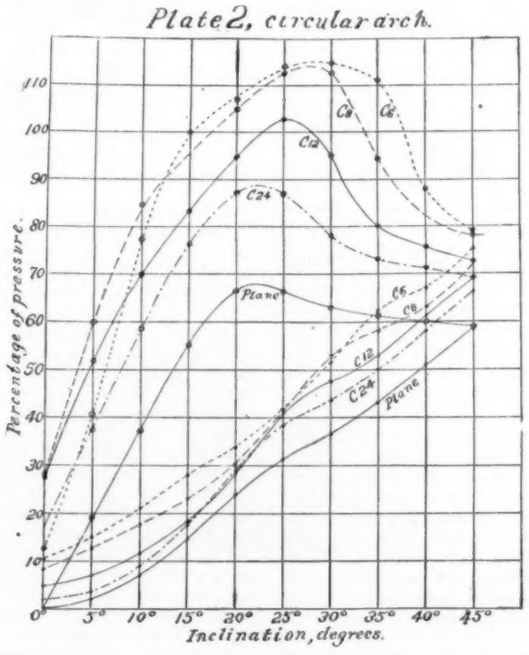
inch deep and P8 being ¾ inch deep, as shown in Fig. 8. In Plate 4 these values are plotted, being each nearly a straight line for lifts up to 15 deg.

In comparing these shapes with a view to adopting the best, we may consider the weight which one pound thrust or pull will propel at soaring speed; this might be called the thrust efficiency, and equals the lift divided by the drift. Table 8 gives this ratio.

At very small angles the plane is most efficient; the C24 (curvature 1 in 24 circular arc) is the best around 5 deg., and the shape marked 1/3 around 10 deg.

In considering the weight carried per horse-power, it is necessary to assume a certain weight per square foot of surface; because, other things except speed being equal, the weight carried per horse-power varies

Plate 2, circular arch.



cupped disk gave a greater unit pressure at 90 than a plane, though the disk was smaller and should interfere less.

Tables 3 and 4 give the lift and drift of four shapes, being a circular arc in profile, and having curvatures from 1 in 24 to 1 in 6.

In Plate 2 these values are plotted. It is seen that a 1 in. 6 curvature (C6) gives at small angles decidedly lower values than the others. The angle of inclination

ble effect of interference, it is not the case. Table 5 gives the values for a cupped disk, that is the section of a spherical surface 6 inches in diameter and ⅝ of an inch deep. The computed drift at 90 deg., i. e., the resistance when normal, would be 63 grammes, but the observed drift was 70 grammes, and the maximum observed lift is 77.5 grammes. This shape, while exerting considerable lift, is not efficient, as the drift is also considerable.

TABLE VIII. EFFICIENCY RATIO $\frac{L}{D}$.

Angle deg.	Plane	C 24	C 12	C 8	C 6	(34)	P 12	P 8
0	...	10.4	5.9	3.3	1.2	5	6	4.1
5	11	10.5	7.5	4.8	2.7	6.9	7	5.2
10	5.4	6.5	6.2	4.7	3.7	6.6	6	4.9
15	3.8	4.4	4.6	4.1	3.6	5	5.1	4.1
20	2.7	3	3.4	3.5	3.2	3.8	3.9	3.2

directly with the square root of the area per pound of weight. Calling W weight, P power, V velocity, K the constant for wind pressure, all in pounds and miles per hour, and L the lift percentage, E the efficiency ratio, and T the thrust we have:

$$W = V^2KAL \quad V = \sqrt{\frac{W}{KAL}}$$

and taking $W = 1$, pound $V = \frac{1}{\sqrt{KAL}}$

$$P = TV \quad T = \frac{1}{E} \quad P = \frac{V}{E}$$

$$\text{Horse-power} = \frac{88P}{33{,}000} = \frac{P}{375} = \frac{V}{375E} = \frac{1}{375E\sqrt{KAL}}$$

The horse load or pounds carried per horse-power $= 375E\sqrt{KAL}$.

Any shapes may be compared as to their relative horse loads by comparing the numerical product of $E\sqrt{L}$ for each. So far *skin friction* has not been considered; it was deducted from the drift together with the head resistance, as before stated. However, it is not negligible, and at high velocities constitutes a large part of the total resistance. Prof. Zahm has shown (paper on atmospheric friction communicated to the Int. Aero. Congress of 1904) that the unit skin friction increases as the 1.85 power of the speed, and diminishes slightly with increasing length of surface in the direction of motion, the formula being $F = 0.0000158\ C^{-.2}\ V^{1.85}$ in miles per hour per square foot, counting one side of the surface (i. e., a square foot plane would be twice this).

TABLE IX. WEIGHT CARRIED PER HORSE-POWER.
1 square foot per pound. K=0.003.

	Angle 5 deg.			Angle 10 deg.		
	Plane	C 24	C 12	C 24	C 12	(34)
Miles per hour Speed	42	30	25.4	24	22	23.6
Weight per H. P. frictionless surface	98	132	111	102	106	105
Weight carried including friction	72	112	102	95	100	99

Table 9 gives the horse load for some of the best shapes at 5 deg. and 10 deg. and for 1 square foot per pound, taking $K = 0.003$. Langley gives K the value 0.0036, Froude 0.00366, Dynes 0.0029 and Stanton (Nat. Phys. Lab.) 0.0027. It is probable that for large surfaces, such as are used in aviation, K will be between 0.003 and 0.004 (probably nearer the latter).

If we assume 2 pounds per square foot of surface, then the C24 shape at 5 deg. will carry 94 pounds, or 80 pounds including friction, at about 42 miles per hour; and with ½ pound per square foot the values are 185 and 156 pounds. A number of other shapes were tried, but were found less efficient than these; but this does not mean that the best shapes have been found, and this will be investigated further. Some experiments were made to determine whether it would be of advantage to place the more strongly curved portion of a shape in the rear, using a surface of gradually increasing curvature from front to rear, as shown at *I*, Fig. 8. Several forms were tried, and gave greater lift in this position, but the drift was so much greater that the efficiency was less in every case.

Though the lift and drift of a plane can be computed from the normal pressure on it at the particular angles, this cannot be done with arched surfaces, because the resultant pressure does not act normal to the chord of the arc, but probably normal to that portion of the surface which is at the center of pressure; and this changes more or less with each different angle of inclination. It would seem then that if the center of pressure were determined for each desired angle, we might assume the resultant pressure to act normal to the surface at that point, and thus obtain the proper angle for computing the lift or drift from the normal pressure. I have determined the centers of pressure for a number of shapes, using a specially devised apparatus, and shall consider this matter in connection with those results.

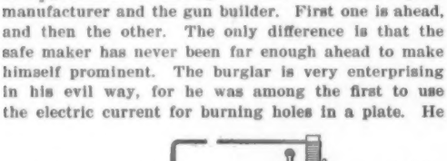
June 1st, 1908.

THE BURGLAR AND THE SAFE MAKER.

AN ELECTRICAL GUARD OF SIMPLE CONSTRUCTION.

BY GEORGE P. PEARCE.

THE fight between the burglar and the safe maker is very similar to the fight between the armor plate manufacturer and the gun builder. First one is ahead, and then the other. The only difference is that the safe maker has never been far enough ahead to make himself prominent. The burglar is very enterprising in his evil way, for he was among the first to use the electric current for burning holes in a plate. He



DEVICE FOR MAKING A SAFE BURGLAR-PROOF.

took advantage of "thermit," and now he is getting quite handy with the oxy-acetylene blowpipe. Any attempt to discourage him with ethyldichloracetate fumes, or other noxious or dangerous vapors, as suggested, would surely be a failure, for a modern safety helmet would enable him to attend to his business without much inconvenience. The following is a description of an attachment for protecting safes, which in my opinion would possibly check successful attempts at burglarizing for some time at any rate.

Let an electric contact device be made along the lines suggested in Fig. 1. The top plate *A* being a sheet of thin springy brass, and the frame *B* a casting. The coil *C* is a resistance, the contacts *D* and *E* are of platinum, and the connections are as shown. In assembling, the plate *A* should be slightly sprung out, as shown, so as to cause a good contact between *D* and *E*, and then the whole box hermetically sealed. This device would be suspended inside the safe, the wires brought out through air-tight joints and connected to the alarm, shown diagramatically in Fig. 2, which could be placed in any desired location. In operation, the safe would be closed as usual, and the current switched on. This would cause a large current to flow through the contacts *D* and *E*, and the electro-magnets *G* and *H*. This current would cause *G* to attract *J*, closing contact *K* and thus throwing in circuit the auxiliary current and ringing the alarm. Next it would be necessary to obtain a partial vacuum in the safe by means of a small pump. This would cause the air confined in the contact device to push the spring surface *A* outward, thus breaking the contact between *D* and *E*. The current will still be able to flow through the resistance coil *C*, but it will be greatly weakened, and the electro-magnet *G* will not be powerful enough to hold *J*, which will fall and catch on step *I*. Magnet *H* will still be magnetized enough to just overcome the tension of the spring *L* and thus keep *I* in position; thus contact at *K* will be broken, and the alarm will cease to sound. The partial vacuum will also cause the door to be tightly drawn against the rubber packing and thus prevent leakage.

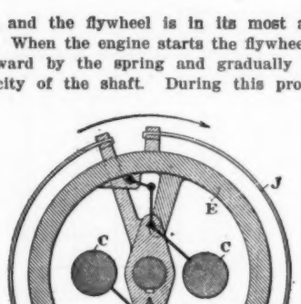
Now as soon as a burglar makes a hole in the safe, the air will rush in, and spring plate *A* will return to its first position and close the short circuit. The extra current will magnetize *G* to a greater extent and cause it to pick up *J*, closing its contact with *K*, and operating the alarm. Should the burglar cut the wires, the magnet *H* would lose its magnetism, and *I* would be drawn back by the spring *L*, allowing *J* to fall and make contact with *K'*, thus again operating the alarm. A resistance could not be inserted between the line wires to balance the resistance coil *C* while the wires were cut, because the resistance of *C* would be unknown. If the new resistance was too great, or too small, it would either cause the magnet *G* to lift *J* and ring alarm through the contact *K*, or it would decrease the power of magnet *H*, which could not then overbalance the spring *L*, which would pull *I* back and let *J* fall and close the contact *K'*, and again ring the alarm. Any attempt at testing the wires would also disturb the balance in the alarm box and cause the signal to be given, and thus it would certainly be a difficult matter to get the valuables without sounding the alarm.—Machinery.

THE LENTZ AXIAL GOVERNOR.

THE balls of this governor move about pivots placed at the ends of a rhomboidal support, which is keyed to the shaft. The rods to which the balls are attached are continued, obliquely, beyond the pivots and are connected, by links, with the rim of a loose flywheel. The couple produced by the centrifugal force of the balls, transmitted to the flywheel through the rods and links, is opposed by a static couple due to the tension of a circular spring, which surrounds the flywheel. One end of this spring is attached to the flywheel, the other to a spoke fastened rigidly to the shaft.

The initial tension of the spring can be varied by means of an extending pin which is actuated by a wedge inside the shaft, the wedge being moved by a screw which terminates in a small wheel outside. Not only can the tension be regulated in advance for the speed devised, but a change of several per cent can be made in the number of revolutions while the engine is running.

When the engine is at rest the balls are nearest the axis and the flywheel is in its most advanced position. When the engine starts the flywheel is carried forward by the spring and gradually acquires the velocity of the shaft. During this process the



THE LENTZ AXIAL GOVERNOR.
A. Support. B. Pivot. C, C. Balls. D. Link. E. Flywheel. J. Spring.

balls diverge until their centrifugal force produces a couple which balances that of the spring.

So long as the energy supplied is equal to the work done these couples remain *in equilibrio* and the flywheel and the shaft revolve with the same velocity.

If the speed of the shaft is checked by an increase in the load, the flywheel gains on the shaft in virtue of its inertia, which, aided by the inertia of the balls, causes the latter to approach the axis and increase the opening of the steam inlet by means of appropriate mechanism. The speed of the shaft is thus accelerated until it again becomes equal to the speed of the flywheel for which the spring is set.

If, on the other hand, the speed of the shaft is momentarily increased by a diminution in the load, the flywheel lags behind, the balls diverge, the spring is stretched and the steam is partly cut off.

This governor is very sensitive, for it acts in response to a tendency to change speed, without waiting, like most axial governors, until the change has taken place. Hence the regulation is almost instantaneous and the speed very nearly uniform.

To Harden Ceresine.—To melted ozokerite (ceresine) or other melted hydrocarbons, add about one-fourth the quantity of oxidized oil and 3 per cent of sulphur. The mixture is heated at a temperature of 201 deg. F., until it has acquired the desired consistency, whereupon it is molded or worked up in other ways. The mass is a substitute for rubber and other waterproof and non-conducting material.

MODERN ORDNANCE.

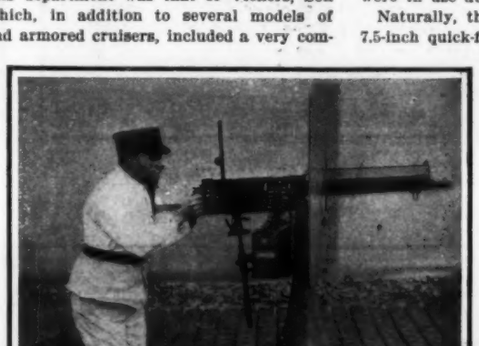
SOME WONDERFUL WEAPONS EXHIBITED AT THE FRANCO-BRITISH EXHIBITION.

AT the Franco-British Exhibition held this year in London, the display of modern ordnance attracted a large share of public attention. The most complete display in this department was that of Vickers, Son & Maxim, which, in addition to several models of battleships and armored cruisers, included a very complete exhibit of rapid-fire guns, ranging from the heavy 7.5-inch piece down to the little rifle-caliber automatic, capable of delivering 500 shots a minute. It is impossible within the limits of the present article to give any detailed description of the several pieces; nor is it necessary, since the weights, velocities, rates of fire, etc., are given in the captions beneath the illustrations of the several guns on the accompanying pages.

Speaking broadly, however, it may be said that this display embodies the very latest developments in the improvement of rapid-fire ordnance; such as wire-wound construction; the use of the Welin breech mechanism, in which the weight of the breech plug is reduced and its rapidity of operation increased; the use of devices to prevent premature firing of the charge; and a general reduction of weight, particularly in the smaller guns, obtained by the use of special grades of steel and alloys, possessing great strength in proportion to their weight. Particularly interesting are the new patterns of rapid-fire field and mountain guns—the range and rapidity of fire of these marking a great advance over the guns which were in use during the late Boer war.

Naturally, the most attractive gun is the powerful 7.5-inch quick-firer on a center pivot mounting. This piece is of the wire-wound type, and fires a 200-pound projectile with a muzzle velocity of 3,000 feet per second. The breech screw is of the Vickers-Welin type, in which the threads are arranged in segments or steps of varying radii, a construction which gives a greater proportion, and a more even distribution, of threads than is possible in the ordinary interrupted screw. The breech is opened or shut by a single horizontal swing of a hand lever. This action locks or unlocks the breech screw, and screws it into or out of the gun, at the same time operating the firing gear. Obturation is effected by means of a plastic pad with a metal protecting disk and rings, this obturator being retained in front of the breech screw by an axial vent which, at its rear extremity, takes the firing gear. The mounting is of the naval casemate type, and consists of a steel top carriage resting on a horizontal roller bearing on a steel pivot. The sights are of the day-and-night sight telescope pattern, and are fitted on both sides of the mounting. They are connected together by straight through spindles, so that they receive simultaneously the same range and deflection. Although this gun weighs 28½ tons, a rapidity of fire of eight rounds per minute has been attained. This piece is mounted extensively on the later cruisers of the British navy.

Particular interest attaches also to the 4-inch quick-fire gun, since this is the caliber which has been adopted for the torpedo-repelling armament of the latest British "Dreadnoughts." Although the gun with its mount weighs only a little over four tons, it has a muzzle energy of nearly 2,000 foot tons, and has attained a velocity of fire of fifteen rounds per minute. The barrel is of the same steel and wire construction as the 7.5-inch piece, and it possesses the same single-motion type breech mechanism. The length of recoil is considerably greater than obtains in the average naval mounting of this class, which enables the stresses due to firing to be reduced to a minimum, as is also the weight of the mount and the working parts. The sights are of the Vickers "Follow-the-Pointer" type; they are provided with telescopes for both gunners, and are cross-connected, so that both telescopes receive simultaneous setting for range and deflection. The dials are fixed on the left-hand side of the mount, and are operated by a gunner set apart



MAXIM AUTOMATIC ON CONE MOUNT.

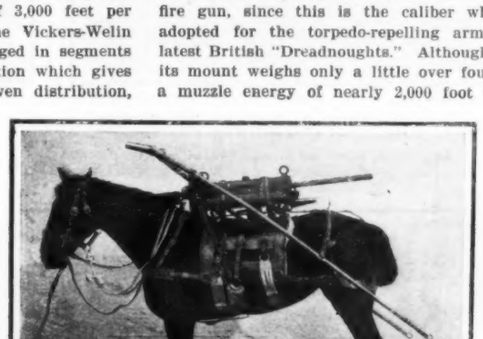
Weight gun, 39¼ pounds; mount, 193 pounds. Fires 500 rounds per minute.

VICKERS AUTOMATIC ON QUADRUPED MOUNT.

Weight gun, 39¼ pounds; mount, 40 pounds. Fires 500 rounds per minute.

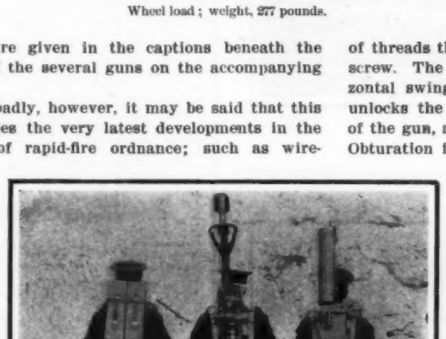
12½-POUNDER MOUNTAIN GUN.

Wheel load; weight, 277 pounds.



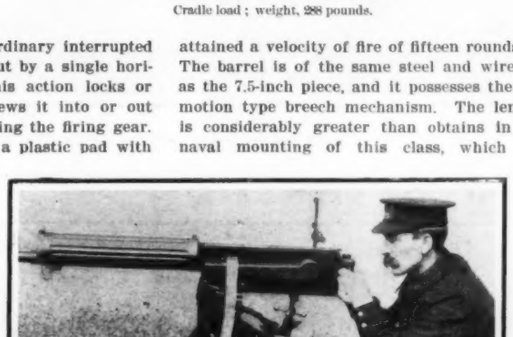
12½-POUNDER MOUNTAIN GUN.

Cradle load; weight, 288 pounds.



VICKERS AUTOMATIC R. C. GUN AND TRIPOD.

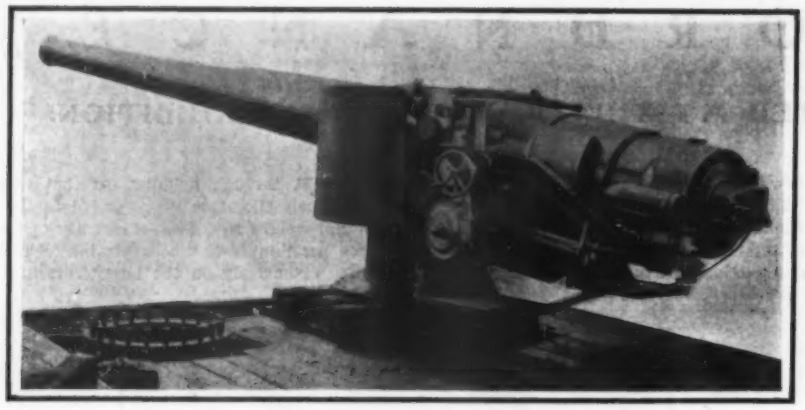
Carrying equipment. Respective loads are 52, 54¾, and 54¾ pounds.



VICKERS R. C. AUTOMATIC ON ADJUSTABLE TRIPOD.

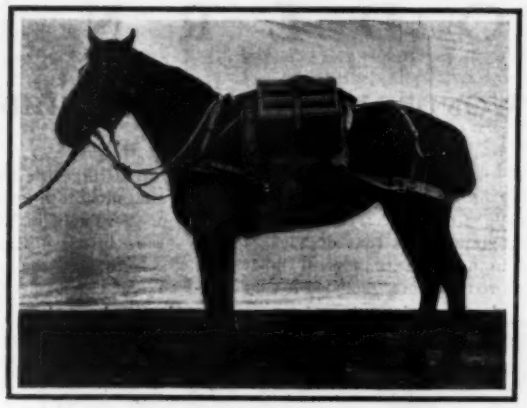
Highest firing position.

MODERN ORDNANCE AT THE FRANCO-BRITISH EXHIBITION.



7.5-INCH B. L. GUN ON PEDESTAL MOUNT.

Weight gun and mount, 28¼ tons. Weight shell, 200 pounds. Velocity, 3,000 foot seconds. Fires 8 rounds per minute.



MOUNTAIN GUN EQUIPMENT.

Ammunition load; weight, 288 pounds.

MOUNTA PMENT.

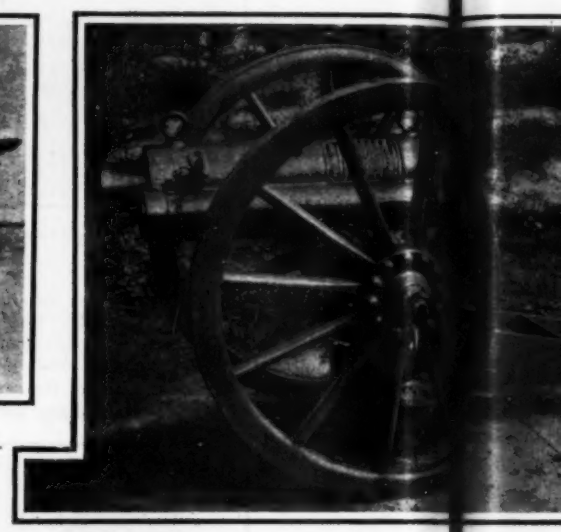
Trail l nds.

MAXIM AUTOMATIC ON COMBINED CARRIAGE AND TRIPOD.

Weight gun, 39¼ pounds; mount, 282 pounds. Fires 500 rounds per minute.

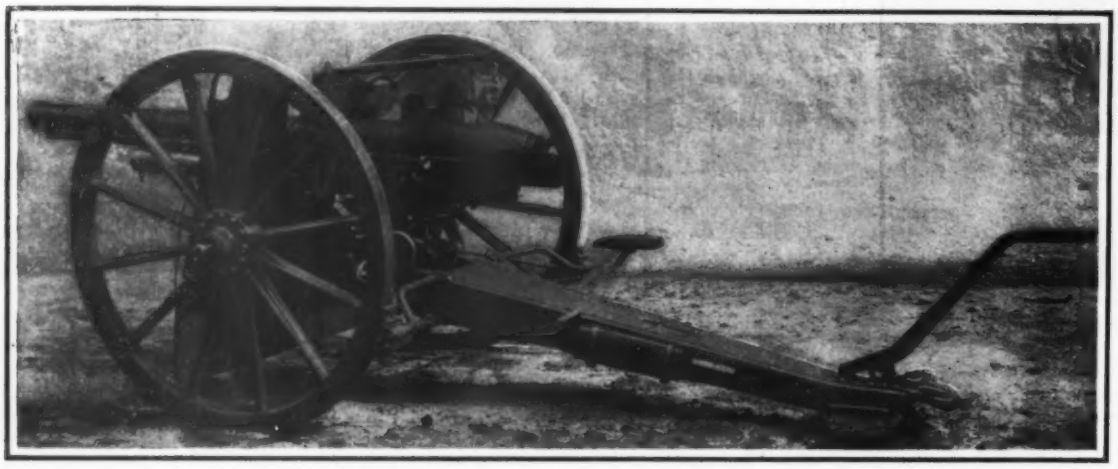
1-POUNDER AUTOMATIC GUN ON MOUNTAIN CARRIAGE.

Weight gun and carriage, 7¾ hundredweight. Fires 800 one-pound shots per minute.



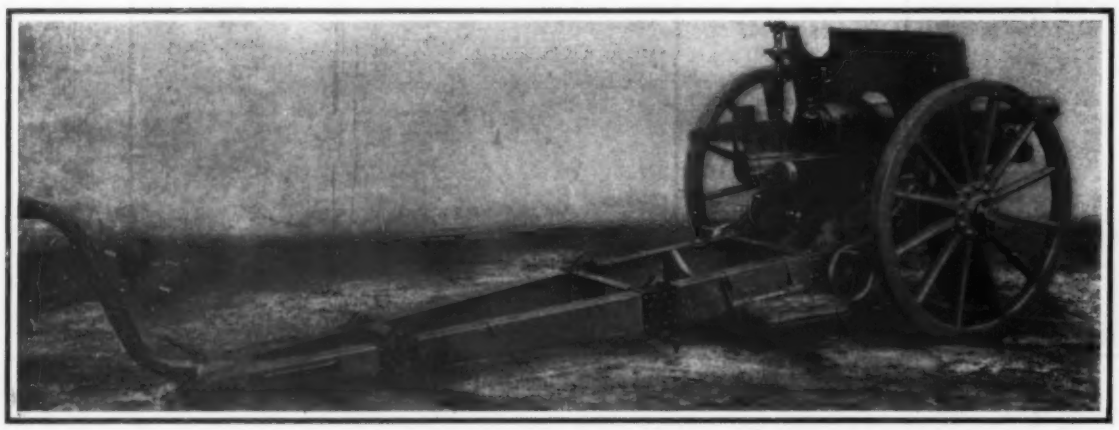
12½-POUN IN GUN.

A remarkable display of weapons rangi eavy 7.5-inc automatic capable of delivering 500 shots a The display ments in the improvement of rapid-fire ord wire-woun Welin breech mechanism, in which the weig ech plug i operation increased; the use of devices to nature firing reduction of weight, particularly in the



12½-POUNDER RAPID-FIRE FIELD GUN ON CARRIAGE.

Weight, 21¾ hundredweight. Weight of shot, 14⅛ pounds. Velocity, 1,640 foot seconds. Rate, 20 rounds per minute.



12½-POUNDER MOUNTAIN GUN.

Weight gun and carriage, ⅛ ton; shot, 12¼ pounds. Velocity, 1,150 foot seconds. Rate, 7 rounds per minute.

6-POUNDER RAPID-FI DESTAL M

Weight, 17⅛ hundredweight. Weight of shot, 6 po 0 foot seconds

MODERN ORDNANCE AT T CO-BRIT

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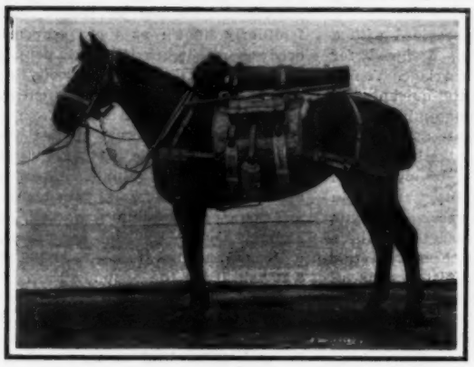
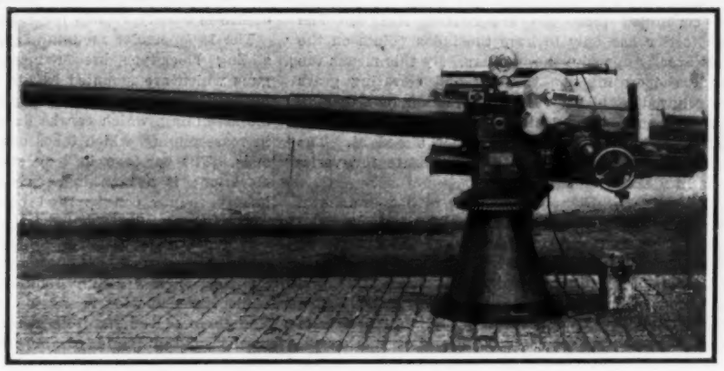


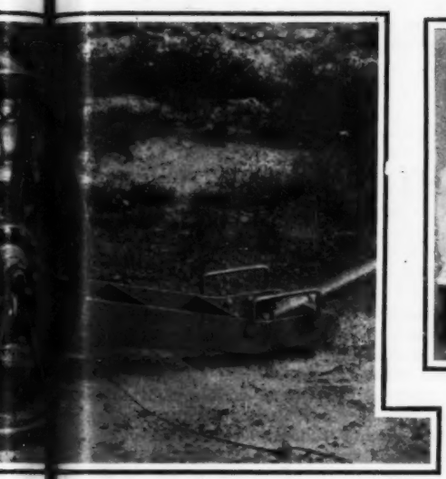
MOUNTAIN GUN EQUIPMENT.

Gun load: weight, 296 pounds.

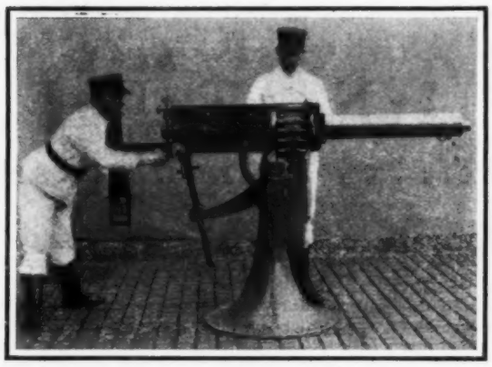


12½-POUNDER, SEMI-AUTOMATIC GUN.

Weight, 2 tons. Weight of shell, 12¼ pounds. Velocity, 2,540 foot seconds. Fires 20 rounds per minute.



IN GUN.



1-POUNDER AUTOMATIC GUN ON CONE MOUNT.

Weight gun, 7⅛ hundredweight; shell, 1 pound. Velocity, 1,800 foot seconds. Fires 300 rounds per minute.

VICKERS AUTOMATIC R. C. GUN ON ADJUSTABLE TRIPOD.

Lowest firing position. Weight gun, 39¼ pounds; tripod, 34 pounds. Fires 500 rounds per minute.

heavy 7.5-inch piece down to the rifle-caliber
The display embodies the latest develop-
wire-wound construction; the use of the
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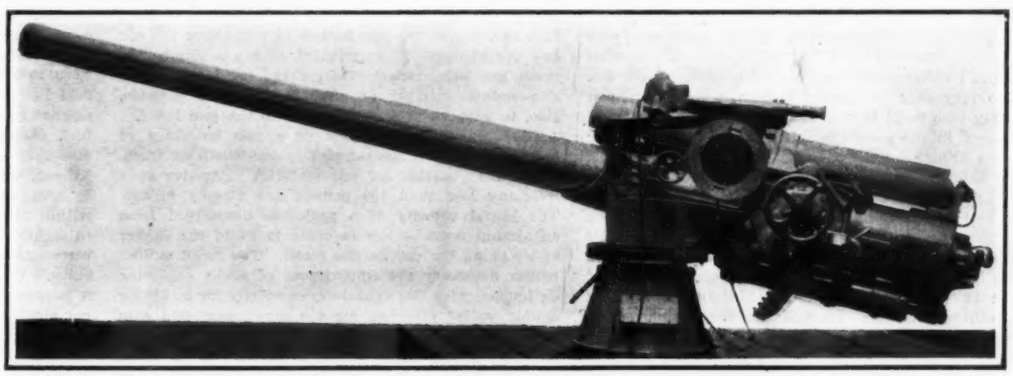
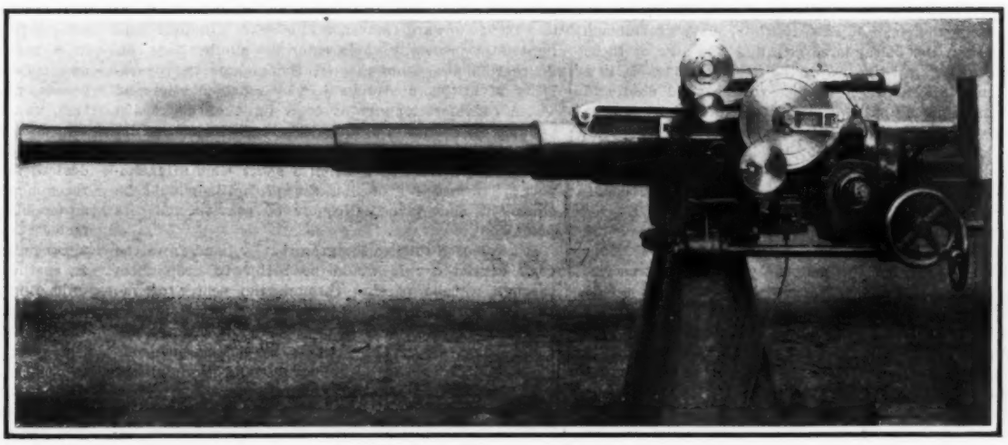
ature firing of the charge; and a general



4-INCH RAPID-FIRE GUN ON PEDESTAL MOUNT.

Weight, 4 tons 2 hundredweight. Weight of shell, 31 pounds. Velocity, 3,000 foot seconds. Fires 15 rounds per minute.



PEDESTAL MOUNT.

foot seconds. Rate, 20 rounds per minute.

6-POUNDER SEMI-AUTOMATIC ON PEDESTAL MOUNT.

Weight, 1 ton. Weight of shot, 6 pounds. Velocity, 2,600 foot seconds. Rate, 25 rounds per minute.

CO-BRITISH EXHIBITION.

for that purpose. The range and deflection pointers are controlled from the fire control station. The sight setter has only to keep the index points on the dials exactly opposite the pointers. By this means the gunners operating the training and elevating gears are relieved of all the usual distraction of attending to sights, and have only to keep the cross lines of the telescopes continually on the object aimed at. The sights have adjusting gear to compensate for variations in muzzle velocity.

Three 12½-pounder guns of 3-inch caliber are shown—a field gun, a mountain gun, and a semi-automatic piece. The field gun consists of an inner tube, on which is shrunk a jacket extending the whole length of the gun. The jacket is provided with longitudinal projections, forming guides for the gun when moving in the cradle. The gun is connected to the rods of the buffers and screen cases by means of lugs on the lower part of the breech ring. The breech mechanism is opened and closed by a single swing of a horizontal lever.

The combined shield and seats are fixed to the axles. The shield is of bullet-proof steel, and the lower part is hinged to give greater protection in action. The gun with carriage weighs a little over one ton. The muzzle velocity is 1,640 feet per second; the projectile weighs 14.33 pounds; and the rapidity of fire is twenty rounds per minute.

The 12½-pounder mountain gun is provided with a sliding block-type breech mechanism, designed for guns which are mounted low in the carriage. A feature which distinguishes this gun is the quickness in disassembling, which can be done in one minute, and in reassembling, which takes one minute and five seconds. The carriage is very steady at all angles of elevation; it has an independent line of sight; and twenty rounds can be fired per minute. The main part of the cradle is cylindrical, and receives the gun and supports the same from the breech to within a few inches from the muzzle. On each side of this cylinder is a hydraulic buffer, the piston rods of which are connected to lugs on the breech of the gun. The force of the recoil is checked in the buffers by means of the liquid passing through grooves from one side of the piston to the other. Round the piston rods are two spiral springs; these are compressed during the recoil, and bring the gun home in firing position.

Two 6-pounder guns are shown: a semi-automatic, weighing, with mount, 1 ton, and capable of firing twenty-five rounds per minute at a velocity of 2,600 feet a second, and a quick-fire gun weighing 17½ hundredweight, firing the same number of rounds a minute at 2,500 feet per second. The automatic gun, familiarly known as the "pompom," weighs 3 hundredweight, 3 quarters, 12 pounds, and fires its 1-pound projectile with a velocity of 1,800 feet a second. The action of the gun is entirely automatic, the gun being fed with cartridges from a belt. The firing is controlled by pressure applied to the trigger lever in the rear, and the shots are delivered at the rate of 300 rounds per minute. Three types of this gun are shown, namely, a 1¼-pounder on naval mounting, a 1-pounder mountain gun, and 1-pounder of cone mount. The 1¼-pounder has a velocity of 2,300 feet a second, and its rate of fire is 250 rounds per minute. The velocity of the 1-pounders is 1,800 feet per second, and each fires 300 rounds per minute.

One of the most interesting exhibits is the method of packing the 12½-pounder mountain gun for transit on mules, the load on each animal and method of division of the parts being clearly shown in our illustration. The gun and carriage weigh 7½ hundredweight, and the piece fires seven 12½-pound shots per minute at a muzzle velocity of 920 feet per second.

Three automatic guns of the R. C. or rifle-caliber type are shown on various types of mount, particulars of which also are given beneath the illustrations.

BATTLES IN THE SKY.

THE MILITARY UTILITY OF THE AIRSHIP.

BY MAJOR GOEBEL.

BALLOONS performed valuable service in the battlefield within a decade after the construction of the first practicable balloon, and the honor of both innovations belongs to France. The first manned balloon ascended from Paris only a few years before the outbreak of the French Revolution, and in 1794 a well-organized balloon corps was attached to the army which invaded Belgium. In the battle of Maubeuge this corps, with the aid of its balloon, was able to keep the French commander accurately informed of the positions and movements of the Austrians, who in vain attempted to bring down the balloon with 17-pound balls, fired from howitzers. The second shot came very near hitting the balloon, which thereupon simply rose until it was out of range. The battle of Fleurus, in the same campaign, was decided in favor of the French by the operations of the balloon corps. The balloon floated about 1,300 feet above the heads of the enemy and did not change its position during the battle, although a number of shots passed between the gasbag and the car. At Mannheim, however, the balloon was so seriously injured by the enemy's fire that it had to be hauled down for repairs.

In the American civil war (1861-5) the military balloon won new laurels and was first employed according to modern methods. By means of two balloons, the balloon corps not only announced the position and movements of the enemy but directed the fire of the artillery so effectively that the enemy's batteries were quickly silenced. A very important improvement was the sending of telegraphic dispatches from the balloon to the troops in the field and even directly to the government at Washington.

During the siege of Paris (1870-1) sixty-six balloons rose from the beleaguered city and fifty-nine of these balloons escaped the fire of the German guns. It is a difficult task to hit a balloon with a solid shot and at that time no satisfactory shell exploded by a time fuse had been invented. Krupp devised a special cannon, easily moved and capable of great elevation, but it fired shells which exploded by contact. In capturing balloons, the infantry, in favorable conditions, had better success than the artillery.

In the Boer war the artillery was more successful. The Boers brought down several English balloons with shrapnel, but the balloons were of great service in discovering the positions of Boer batteries, in directing the English artillery fire, and especially in discovering the exact location of General Cronje's camp at Paardeberg. In the war between Russia and Japan (1904) little injury was inflicted on the balloons of either side by the guns of the enemy, but, according to the experience of the Boer war, this was the fault of the gunners rather than the shells, but was probably due chiefly to the great distance of the balloons.

Future wars will bring into action rapid dirigible balloons, which will make further demands on gunners and projectiles. The work of these airships will not be confined to observing and reporting the positions of the enemy and directing gunfire. They will also be required to drop explosives upon the enemy and to drive off or destroy the enemy's balloons. The former task offers no special difficulty, but the discharge of firearms from a balloon filled with inflammable gas would appear to be exceedingly hazardous. Little flame, however, issues from the mouth of a gun of small caliber (and no other could be used in a balloon), and the new nitroglycerin and nitrocellulose powders made by a Berlin firm produce no flame whatever. Furthermore, the small quantity of hot gas discharged would be quickly cooled and dissipated, especially at great altitudes. Very little risk would attend the use of small guns on Zeppelin's airship, in which the aluminium hull is 16 feet above the car and the hydrogen is distributed among a number of small gas bags, separated from the rigid shell by a non-conducting layer of air. It would be possible, also, to adopt a protective device to the gun itself.

The Zeppelin airship has an excess buoyancy of one ton, and the Parseval airship one-fourth as much, which are available for war material. Effective guns weighing less than 100 pounds are already in use. The initial velocity of a projectile discharged from an airship must be low in order to avoid the danger of wrecking the car by the recoil. The small caliber makes necessary the employment of shells exploding on impact, with two exploders, especially for attacking double walled airships, for the inner, non-rigid skin would successfully resist shrapnel moving with considerable speed. Hand grenades would be convenient weapons to employ against hostile balloons, after rising above them. In these grenades a certain amount of weight is necessary to prevent deflection by the wind and to insure penetration, but the grenade must not be heavy enough to use up too much of the available carrying power or to cause, when it is dropped, a violent upward movement of the airship. The lighter the projectile, the greater the number that can be carried and, consequently, the greater the probability of hitting a given object by repeated attempts. These considerations point to a limit of about 100 pounds. Grenades weighing 22 pounds have been introduced in France. An essential requirement is an exploder operating at a definite short time after impact. To insure explosion the projectile should be elongated and have its center of gravity near its point.

Instead of throwing the grenades by hand from the edge of the car it would be better to drop them through a tube passing through the center of the floor. In this way the equilibrium of the airship would be less disturbed and some initial velocity could be given to the grenade by springs or compressed air. This initial velocity would diminish the deflecting influence of the wind.

Even the swaying of a captive balloon makes it difficult to hit a small object, such as a detached battery, and the difficulty is increased when the balloon is in motion. At present about 2,600 feet is the upper limit of the flight of large dirigible balloons, but even from this height it is very difficult to hit a small object.

In regard to the danger which threatens the balloon from below, it should be remembered that volleys of infantry are effective to a height of 5,000 feet, in disabling the crew, while shrapnel very seriously endangers the balloon itself. A discharge of shrapnel is a conical shower of projectiles which may number as many as 1,500 with a gun of large caliber. A volley of six such discharges from a favorable position subjects the balloon to a hailstorm of bullets, many of which perforate the bag and cause a gradual loss of gas. The only necessary condition is that the shells shall pass over the balloon, for the rain of shrapnel is directed downward. If the shell explodes very near the balloon, the whole mass of gas is ignited. The height to which a shell can be thrown depends upon both the elevation and the maximum range of the gun. Field pieces carry to heights from 2,600 to 3,300 feet, mountain howitzers to 4,300 feet, field howitzers to 6,000 feet. Heavy siege and coast-defense guns attain much greater heights, up to 13,000 feet. A captive balloon, which can move only up or down, is in very much greater danger than a free balloon, whether dirigible or not. It has been proved by numerous experiments that a captive balloon, if within range, can be brought down by shrapnel fire in eight or ten minutes. It is difficult to make corresponding experiments with free balloons and airships. In the case of the free non-dirigible balloon it is necessary to await a favorable wind, and at present airships can only be represented, very imperfectly, by ordinary balloons moved with ropes. In an experiment made in Danzig Bay last year, a free balloon at an elevation of about 1,000 feet was brought down by a battery of 4-inch guns some 21,000 feet distant.

A dirigible airship can move out of range more easily, but in order to perform its military duty it is restricted to a definite place and height and its great size makes it a comparatively easy mark. It is in danger from any given gun, however, only when it is at a horizontal distance depending on the elevation and trajectory of that gun. As it comes nearer it passes out of range of the gun at its maximum elevation, and lateral deviations are very difficult to follow with large guns. Light guns of great horizontal and vertical range, mounted on automobiles, have been devised for the pursuit of airships. Some authorities recommend a gun of small caliber on an armored automobile, others a larger gun, carried by an unprotected car. In the latter case the automobile is merely a conveyance. The great gun cannot be fired from it, as the car would be wrecked by the recoil. The unloading and mounting of the gun involves a delay which in many cases would allow the airship to escape. The omission of armor, which is made necessary by the weight of the great gun, would expose the vehicle to attack in transit and call for a strong escort to defend it both in transit and during the unloading and mounting. Yet the unarmored car with the large gun would be little lighter than the armored car with the gun of smaller caliber. The total weight of Ehrhardt's armored car with its 2-inch gun, ammunition, and crew is 7,040 pounds, distributed as follows: Car and armor, 4,740 pounds; gun, 880 pounds; 100 projectiles, 650 pounds; 5 men, 770 pounds.

An increase of only 0.6 inch in caliber would increase the weight of the gun and 100 projectiles by 1,750 pounds, which would nearly offset the weight of the armor. Ehrhardt's armored car has a 50 to 60 horse-power gasoline motor and a normal speed of 28

miles per hour. It takes grades up to 22 per cent on poor roads and can even traverse fairly difficult ground without roads.

The gun can be trained on the airship while the car is in motion. When all is ready the car stops, four posts are cast loose and fall into positions in which they relieve the pressure on the springs, and the shot is fired. The car is so strongly built that the gun can be discharged, if necessary, without dropping the posts, and the pursuit of the airship can be instantly resumed. A balloon 14,000 feet distant is within range of shells and shrapnel up to a height of 8,200 feet. With the maximum elevation of the gun, a balloon distant 6,850 feet is within range up to a height of 12,000 feet. The shrapnel exploder is so constructed that it throws out, in flight, three arms of brass, the function of which is to catch and tear the skin of the balloon. As all parts, including the wheels, are protected by armor ⅛ inch thick, the automobile can follow an airship beyond the lines without regard to the presence of small detachments of the enemy, and it can move anywhere within the lines, in battle, with perfect indifference to flying bullets. A still more independent and efficient military unit, however, may be made by associating with it, as escort, a lighter armored automobile carrying a machine gun. The accuracy of fire might be greatly improved by means of observations taken from this auxiliary car, stationed a hundred or two hundred yards from the line of fire.

In future wars, therefore, balloons will be exposed to greater dangers than in the past, but they will also have better means of defense. For captive balloons, in many cases, the only possible expedient will be to dodge the enemy's missiles by rising and falling, but the dirigible airship will be able to flee, and to change its direction and speed at will. It can seek the shelter of low-lying clouds and can approach and even attack a camp or a city under cover of the night. It can escape pursuit by automobiles, by laying its course over water, forests or rough and trackless districts. Probably a color can be given to it which will make it almost invisible, and even an airship with an armor-clad car is not an impossibility.—Translated for the SUPPLEMENT from Illustrirte Zeitung.

COAL-WASHING JIGS.

SOME FURTHER IMPROVEMENTS.

BY E. J. MUNBY, M.E.

IN the SCIENTIFIC AMERICAN SUPPLEMENT of August 1 last Mr. Samuel Diescher ably described the reasons for and history of the process of coal washing, in the course of which the deficiencies of the machines used hitherto were pointed out, as well as the attempts that have been made to overcome them.

At about the time at which the article above referred to appeared, trials were in progress at Scranton, Pa., of a new jig, which had already been highly successful in the treatment of the lead-zinc ores of the Joplin district, and its remarkable success in washing coal at those trials makes some description of the jig an effective sequel to Mr. Diescher's paper.

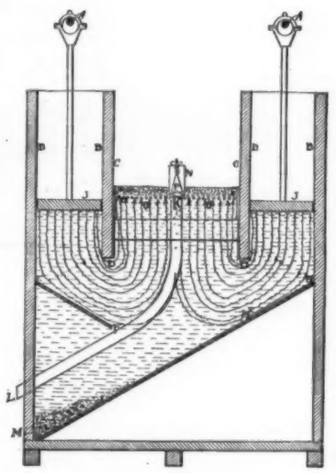
Both as regards dimensions and number of cells, the details of the Foust jig may be altered to any extent to suit particular requirements. In the recent trials at the coal washery of the Dolph Coal Company, Scranton, Pa., for instance, a two-cell jig with 6 x 5 screens was used, and jigs with three 6 x 7 cells are now being installed in an extension of the same plant. For the purposes of description of the usual proportions and essential features, however, the following are the dimensions of a standard pattern of 400 tons per 10 hours' capacity:

The jig consists essentially of a rectangular box built of 4-inch timber, 20 feet long by 10 feet wide and 8 feet high at the feed end and 7 feet high at the discharge end; it is divided longitudinally into four cells, and laterally into three compartments—a central screen compartment, *CC*, 4 feet 6 inches wide and on either side a plunger compartment, *BB*, 2 feet 6 inches wide. The divisions between the cells extend from the top of the box in the plunger compartments and from the screen in the central compartment to the bottom of the box, but the partitions, *CD*, between the plunger and screen compartments extend only 18 inches below the screen. From the front or discharge side an inclined board extends inward from a point level with the bottom of the partition to a point vertically below the latter, forming the "throat" or water passage; while from the opposite side a floor of boards, *GI*, extends from a corresponding point and with the same inclination right across to the bottom of the box at the front side (see sectional view), thus affording an exactly symmetrical "throat," *DF*, *DH*, on both sides with the maximum passage, *FH*, for the "hutch" (or concentrates passed through the screen) to pass to the bottom of the box without piling up and interfering with the pulsion of the water.

Supported centrally above each side compartment is a shaft, *A*, carrying eccentrics operating the plungers, *JJ*; the eccentrics are, as usual, adjustable for a considerable range of throw, and are arranged to lift the plungers on each shaft, not simultaneously, but in rotation, thus distributing the load; but the two shafts are rigidly connected by a link, which insures absolutely synchronous motion of the pair of plungers on opposite sides of any screen.

The automatic draw-off consists of a pipe, *KL*, extending through the screen, one in the center of each screen, and continued down through the lower part of the cell to a draw-off cock, *L*, above that by which the "hutch" is withdrawn at *M*. Around the top of this pipe, which projects only just above the screen, is a "hull" or hollow cylinder, *N*, of larger diameter, supported at an adjustable distance above the screen by a tripod standing upon the screen, *OO*, and extending through and above the bed of ore being treated. Inside this hull is a conical metal valve, *P*, resting upon the bed, and rising and falling with it by an adjustable amount controlled by a spring; the relation of the weight of the valve to that of the bed of material being regulated by the compression placed upon the spring by a thumb-screw, a constant discharge under the hull down the pipe directly from the screen surface is maintained together with a constant thickness of the bed.

The jig, as will be seen, involves no new principle, being dependent, like the Hartz, Cooley, and all others, upon the physical law which causes equal-weighing particles to stratify themselves in order of size and equal-sized particles to stratify themselves in



A TWO-CELL JIG.

order of specific gravity in a pulsating column of water. By means of the double plungers, however, the familiar principle is in so far better applied that much better, more uniform, and more easily controlled results may be obtained by the operation of the Foust jig—results, moreover, much less dependent upon the individual skill and judgment of the operator.

In any single plunger jig, to obtain definite lifting of the bed upon one side of the screen, more pulsion must be applied to the water than is required for a corresponding motion on the other side, from which it follows that the motion cannot be uniform, however careful the design of the throat to properly direct the water current. The uneven opening of the bed thus caused, and consequent variation of interstitial space, permits of the passage through it of particles of a size and order not strictly in accordance with the physical laws governing "equal settling factors," and results in what is known to jig men as "sanding." To prevent this, the operator of other plunger jigs carries a thick bed upon the screen; and as the forward motion of the material down the length of the screen is affected only by the water, it follows that a considerable quantity of water must be used. It also follows that the drawing off of the coarse concentrates from the bed (by means of the Heberle or similar gate) must be high up, and consequently the material drawn off can be neither so heavy nor so uniform as if drawn closer to the screen.

By means of the above-described double plungers in the Foust jig, and the special throat design, an absolutely uniform action of the water all over the under side of the screen is obtained. There is no uneven opening of the bed, the interstitial space remaining as constant as possible and tending to very accurate stratification of the bed, and the combination of these factors permits of the suspended particles of ore, chats, or gangue finding their respective levels with fewer and less violent pulsations of the water columns produced by the plunger, with consequent smaller disturbance of the bed, each condition helping the other.

The combination of the above conditions both materially assists the saving of the fine mineral and reduces the quantity of water required, and these conditions are again mutually interdependent. All losses of fines could not be eliminated were the usual quantity of water required; but with the reduction of suction due to the slow stroke, and the elimination of "sluicing" by the small quantity of water used, the settlement of the different particles is only influenced by something very nearly approaching perfect theoretical jigging conditions. There is no "sanding" (due either to suction or sluicing of gangue particles through the bed), and the saving of the fine float mineral is quite remarkable, and can be more easily demonstrated than described. So delicate is this action, that even the water is classified, that going into the screen with the feed being, of course, muddy, and that drawn off with the clean concentrates being clear.

The advantages of the reduced wash water across the screens is particularly noticeable in the separation of one mineral from another, and the advantage of the thin bed is sufficiently obvious for the separation of the minerals of nearly the same specific gravity, e. g., removing iron pyrites from zinc blende.

The above results being obtainable with a thin bed upon the screen, the advantages of the latter are sufficiently obvious—reduction of wear upon the screens through drag and of water required; a further advantage is the possibility of drawing off at the screen of the most uniform and heaviest concentrates, and this is accomplished in a particularly perfect manner by the Foust automatic gate. The latter draws off from the center of a uniform bed instead of from the side of an unequal one; the pressure of its valve upon the bed being adjustable by compression of its spring, it may be arranged not only to draw off the heaviest concentrates present in each cell, but chats of any desired gravity may be withdrawn to suit the requirements of any subsequent treatment in the comparatively rare case of such being necessary.

Whereas in coal washing the process is reversed, in so far as the lighter coal is discharged at the "tailings" end of the jig and the waste, iron pyrites, slate, fire clay, bone, and other impurities are drawn off the screen or passed through the screens in the different cells in order of their gravities as "concentrates," all the above-mentioned advantages for ore dressing apply equally to coal washing.

There is, of course, no difficulty at all in washing away all the finest "float" coal; and the wide screen, slow speed, and smooth action of the jig prevent any of it being sluiced through into the slate. Similarly, the susceptibility of the jig enables nearly all of the "bone" to be jigged off.

The trials at the Scranton collieries were made with "pea" anthracite containing 40 per cent of waste matter; in this grade of coal the buyers' inspectors allow a maximum of 12 per cent of "bone," the impurity of specific gravity most nearly the same as that of coal, and consequently the most difficult to separate. The washers previously in use are considered to do exceptionally good work if they reduce the percentage of "bone" to 7 or 6, leaving about 5 per cent of coal in the waste; the Foust jig at its first trial left only 2 per cent of "bone" in the coal, and absolutely no coal could be detected in the waste. At the close of the

trial barren waste previously passed through was returned to the jig, all of which was successfully passed through the screen or drawn off by the automatic valve, none of it being added to the coal.

The larger jigs now being built will wash 600 tons per day of the large accumulations of waste material from the mines too fine for hand picking or the product of other washers, containing from 5 per cent to 20 per cent of coal; the rehandling and washing costing less than ten cents per ton of waste, it is expected that a high-grade coal will be recovered at a cost of about one dollar per ton.

THE RINGED AND SMOOTH SNAKES.*

THE MARKINGS OF TWO HARMLESS SNAKES.

BY G. A. BOULENGER.

IN this article I intend to deal with the variations in the markings of two harmless snakes—the ringed snake (*Tropidonotus natrix*) and the smooth snake (*Coronella austriaca*). Most books give as an infallible distinguishing mark of the ringed snake the presence of a yellowish white, bright yellow, or orange transverse marking close behind the head, bordered behind by a black patch. Now this yellow "collar," or "ring," although it appears to be absolutely constant in young specimens, may entirely disappear in adult females. The black transverse blotch on the neck is, however, always displayed in British specimens, although varying much in shape and size, sometimes extending right across the nape, or interrupted in the middle, sometimes produced forward so as to divide the yellow "collar" in the middle. We shall see further on that exceptions occur in Continental specimens. The first photograph here given represents three adult specimens from England, natural size, the two upper figures showing the yellow marking at the back of the head; the bottom figure is one of a specimen without any yellow, and with the black patches on the nape reduced in size and widely interrupted in the middle. As allusion has been made to the sex in noticing these discrepancies from the ordinary type of coloration, it may be well to state how a female can be distinguished from a male. Although not so markedly as in the adder, the shape of the tail will furnish the information. Instead of tapering gradually from the base, as shown in the second photograph, the tail of the male (as shown in the third) is of equal caliber, or even somewhat swollen for some distance behind the vent, which is covered by a pair of enlarged shields. As the annexed figures also show, the tail is generally longer in males than in females, and the number of paired shields on its lower surface varies between sixty and eighty in the former, between fifty and seventy in the latter. Females attain a greater size than males; giants of 4 feet or over, as occasionally occur in this country, are invariably females. The largest British specimen I have seen measures only 44½ inches, and was caught in Wales; but Mr. Aflalo has recorded one of 5 feet 8 inches from the New Forest, while from Southern Europe an example 6½ feet long is known.

The ground color of the upper parts varies from a pale gray to dull green, olive brown, or blackish brown, the lower parts being dark gray or black, or checkered black and white or gray. In what may be regarded as the most primitive pattern of markings, the black spots are disposed with great regularity in eight longitudinal series—four on the back, two on each side, the spots alternating in what is called a quincuncial arrangement. The side spots usually fuse to form vertical bars; this is nearly always the case in British examples, in which we find two rows of small spots along the back, and a series of bars along each side. The black collar-mark is formed by the fusion of the spots of all the series.

TAIL OF FEMALE.

The Rev. O. P. Cambridge has described and figured a curious specimen, found by him on Bloxworth Heath in Hampshire, the upper parts of which were of a uniform pale whitish color, with a well-defined broad longitudinal central dorsal pale yellow-brown band; no trace of the yellow ring at the back of the head was visible. A somewhat similar semi-albino, yellowish, with the markings reddish brown, from Horsted Keynes in Sussex, was sent to the Natural History Museum by Miss Benson. A very remarkable variety, of which numbers may be seen in shops dealing with live animals, and of which escaped specimens have now and then been captured in this country, is the variety *persa*, or *bilineata*, characterized by a yellowish or whitish streak along each side of the back, between the black markings, which can be noted in the upper figure in the fourth picture. It is a native of Italy, Southeastern Europe, and Southwestern Asia. Another variety, from Corsica and Sardinia, is the *Natrix cettii* (middle figure), with the black spots much enlarged, and forming more or less regular bands across the body; the yellow collar has disappeared, and the black patch behind it does not differ from the bars on the body.

BRITISH RINGED SNAKES.

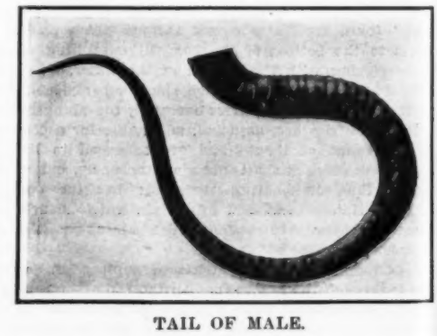
In the variety *astreptophorus* (lower figure), from Spain, the yellow and black markings on the nape, which are present in the young, disappear altogether in the adult. In this variety the belly is usually gray with a broad black median stripe. These examples suffice to show to what an enormous extent the markings may vary within the limits of one well-defined species. Such a range of variation is by no means an unusual thing in snakes, many of these forms having originally been described as distinct species, which cannot be maintained on account of the numerous intermediate types which connect them.

The smooth snake, of which the head and neck are represented on the fifth photograph, derives its name from the absence of a raised line or keel on the scales on the back, which characterizes the ringed snake, and which is also present in the adder. It is a rare British species, first discovered in Hampshire in 1858, and since found in Dorsetshire, Berkshire, and the western parts of Surrey. British specimens do not exceed a length of 28 inches. The color is grayish or reddish brown above, brick-red, purplish, or blackish beneath. This coloration gives it a certain resemblance to the viper, for which it is frequently mistaken; but the pattern of markings, which vary from reddish brown to black, is very different.

There are usually four series of small spots along the body, one pair on the back and one on each side; a dark blotch on the back of the head frequently sends off two branches, which may be confluent with the series of dorsal spots, while a dark streak runs along each side of the head, passing through the eye, and terminates at the angle of the jaws, or may be continued along the neck, joining the lateral series of spots. In some specimens the dorsal spots join across the spine, forming cross-bars. In a specimen from Vienna, the head streaks are continued along a considerable part of the body, and the median pair inclose dark cross-bars which produce a ladder-like pattern on the back. This variety has been called *parietalis*, on account of a pair of small, light, dark-edged spots on the parietal shields, which cover the occiput. It also frequently happens that the middle line of the back assumes a pale yellowish color, bordered on each side by a dark brown band, thus giving the snake a striated appearance. Melanism, which is well known in the ringed snake, must be of rare occurrence in the smooth snake. I have never seen such a melano, but Mr. William Penny has noted the occurrence near Poole of two specimens of a black variety.

One of the most readily observable differences between the harmless snakes and the adder resides in the shape of the pupil of the eye, which is round in the former and contracted to a vertical slit in the latter. Although very ready to bite when first caught, the smooth snake is easily tamed. M. R. Rollinat, a distinguished French naturalist, who has devoted many years to the study of the habits of reptiles, pronounces it to be the most intelligent of the snakes of Central Europe. We here reproduce a series of photographs showing the snake feeding on a wall-lizard while in the hand of M. Rollinat. As observed by this gentleman, the key to the art of taming snakes, and, we might add, most other animals, is to show no fear. They should be handled gently, but without hesitation, and if one does not seem to mind a bite they soon drop their ferocity. The ringed snake hardly ever bites.

The food of the smooth snake consists mainly of lizards, although occasionally it will swallow a slow-worm, a smaller snake, or a vole or mouse. In this country the common or viviparous lizard constitutes its chief diet. It has been believed, from the community of habitat, to show a predilection for the sand-lizard; but adult sand-lizards are, as a rule, too large a prey for the smooth snake, and I doubt whether it makes any distinction between the young of that species and a common lizard of similar size. No case is known of its taking batrachians of any kind. It is a constrictor, suffocating or crushing its prey in the coils of its body before proceeding to swallow it. In all these respects it differs from the ringed snake, which feeds almost exclusively on frogs and toads, which it seizes in its jaws and swallows, regardless of their struggles and screams. The smooth snake is viviparous, or rather ovoviviparous. The embryo is surrounded by a thin, transparent envelope, which it ruptures immediately on leaving the body of the mother, in this respect resembling the adder, the slow-worm, and the common lizard; while our two other reptiles, the common or ringed snake and the sand-lizard, lay eggs protected by a



TAIL OF MALE.

* Country Life (London).

tough, parchment-like shell, which do not hatch until long after they are laid. The brood consists of six to twelve young, measuring 5 or 6 inches at birth.

A SCIENTIFIC ARGUMENT AGAINST GAMBLING.

SIR HIRAM MAXIM has been busily engaged in exposing the fallacy of "systems" for breaking the bank at Monte Carlo. Mr. Herbert Vivian, according to the London papers, is the latest discoverer of a "system." Sir Hiram has apparently demolished him in a series of press interviews, which the Literary Digest presents and which we here reprint for the benefit of our readers.

Mr. Vivian's system is based on the old belief, persistently held by gamblers and others, that the occurrence of a chance event is affected in some way by occurrences immediately preceding it, although physically disconnected from it. Thus, although it is even chances whether a cent turns heads or tails the first time, the chances, they say, are greatly against heads if there has been a "run" of heads immediately preceding it. Such an occurrence is confused with similar series in which the chances are progressively diminished by the gradual exhaustion of a supply. If balls are drawn from a bag containing both black and white, the chance of drawing another black one becomes less and less as each black one is drawn; but if the ball is returned to the bag each time, the chance remains the same as at first. This is proved by mathematics, by experience, and by ordinary common sense, but Mr. Vivian does not acknowledge it. The gambler has only, he says, to watch the roulette table for what he calls a "pattern," the successive occurrence of the same grouping of colors, and then bet against it. He says, as quoted in The Evening Standard and St. James Gazette:

"In theory, doubtless, no spin at roulette is or can be affected by any previous spin. Sir Hiram Maxim and I may come up to a table and find that there have just been twenty blacks. If I were a gambler, I should immediately empty my pockets and stake confidently on red until I was a small fortune to the good. But Sir Hiram Maxim would assure me that the probabilities were still in favor of the bank wherever I chose to place my money."

To this Sir Hiram replies:

"A run of twenty on black occurs once in 1,048,576 coups. It would require a very strong and healthy man to remain in the Casino and watch a table for 333 coups a day for 300 days in a year, or say 100,000 coups, and at this rate one would have to watch the wheel on an average 10.48 years in order to have an even chance to make one's first stake, and then with less than an even chance of winning."

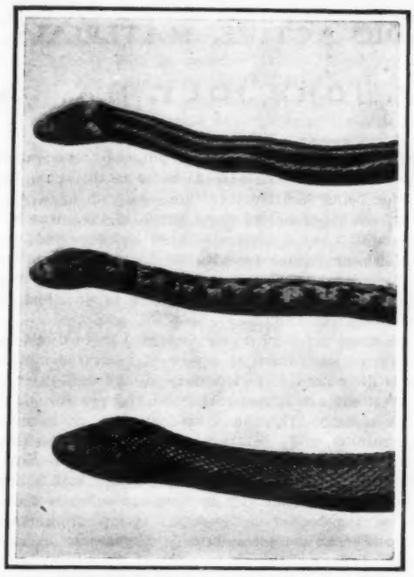
Concerning Mr. Vivian's "pattern" system he says:

"It will be seen from Mr. Herbert Vivian's brilliant system of reasoning that the longer one waits and the longer the run or series or pattern may be, the greater will be the certainty of winning. He suggests that a run of twenty may not always be quite long enough to be safe, and hints that twenty-five might be better, or even thirty if the pattern is a complicated one. It is, therefore, very evident that a run of thirty is better than twenty or even twenty-five. Therefore, if we are to play his best system we shall have to take the pattern of thirty. One pattern is just as liable to occur at roulette as another, and any particular pattern of thirty stands the same chance of occurring that a run of thirty would on red or any other even chance. Consequently the player will have to wait until there has been a run of thirty before he will be able to stake, and in order to win, a prearranged series of thirty-one chances has to occur. A run of thirty-one occurs once in every 2,147,483,648 even chances.

SMOOTH SNAKE.

"If a player has selected the pattern that he intends to play and the chance that has come up in order to win—that is, thirty-one prearranged chances—and has it carefully written down, and is able to watch his table 10,000 coups in a year, he stands one chance in two of encountering a favorable run in every 21,474 years' play.

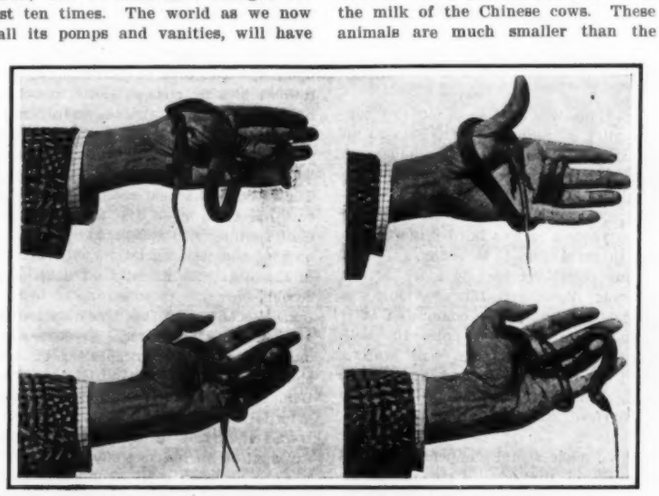
"Suppose, now, that two young gentlemen (twins) should each find themselves in possession of one dollar. Alfred goes to Monte Carlo to play Mr. Herbert Vivian's best system, and James puts his dollar out at interest at 4 per cent. Let us see now how matters will stand at the end of the time when Alfred will have won one five-franc piece. At 4 per cent interest James's dollar will have doubled every 17.67 years; it will therefore double 1,215 times. If he saved it all and didn't spend a cent it would require to pay him off more than a million solid spheres of pure gold, each of which would fill the whole solar system from the center of the sun to the orbit of Neptune and leave enough gold over to build and equip a railway of pure gold, double track, from Ursa Major to the Southern Cross, while Alfred will only have won a five-franc piece. Let us now examine the changes that will take place on this planet by the time that Alfred will have his chance of winning a five-franc piece. Coal and iron mines will have long been exhausted, much high land and some mountain ranges will be submerged in the sea, and much that is now at the bottom of the sea will become dry land. The diameter of the earth at the equator will have become slightly less, while the diameter from pole to pole will have increased. The moon will have absorbed sufficient dynamic energy from the earth to accelerate its orbital velocity, and so increase its distance from the earth, while the length of the days on the earth will be correspondingly increased. The projected pole of the earth will have made nearly one revolution in the northern heavens. For poor humanity great changes will have taken place. All our cemeteries will have been exploited and dug over for the gold in our teeth; all our literature, laws, and languages will have completely disappeared; and we shall have changed our religions at least ten times. The world as we now know it, with all its pomps and vanities, will have forever passed away. Nothing will remain except Alfred, the patient punter, who, like Micawber, is waiting for something to turn up, and the roulette wheel at Monte Carlo, which, like Fate, goes on forever."



SOUTH EUROPEAN RINGED SNAKES.

In another place, Sir Hiram says:

"I often wonder why the gentlemen who write so extensively and so learnedly on the subject do not examine the records of play and count the number of runs of different magnitude before rushing into print. If I found there were twice as many runs of nine as of ten, which is the case, it would prove most conclusively to me that when a run of nine on black had occurred there would be exactly an even chance that it would come up again, and that no advantage could arise from staking on red. As a matter of fact, however, the rapidity with which the geometrical series mounts is so great as not to be within the grasp of ordinary writers, and that is why it is impossible for them to understand it."



SMOOTH SNAKE FEEDING ON WALL LIZARD.

CHINESE CATTLE.

AN American firm is busily engaged at the present time in exporting cattle from the Chinese province of Shantung to Vladivostok, over 1,000 head having been forwarded in the course of a month. The representative of this firm enters the interior of the province, and purchases cattle directly from the Chinese owners, or in the regular market towns, where all kinds of produce are exposed for sale at regular periods. Exports to the Philippine Islands were formerly made from Shantung, but owing to the prevalence of anthrax and other cattle diseases, the importation into the islands was prohibited. Last year the Chinese government prohibited the export of cattle from China to Vladivostok, but the prohibition has apparently since been removed. Recently the importation of cattle into Vladivostok was prohibited by the Russian government officials, but this restriction has been removed. The American consul at Tsingtau says that cattle are not bred in China to any great exent; there are no large cattle ranches, each small farmer breeding such stock as he may himself need. Cows are not used for milk by the Chinese people, but are yoked with oxen, or with any other available animal, and employed in cultivating the fields. Foreign buyers can afford to pay prices which appeal to the owners of cattle, and it is feared that if large exports continue, the country will be depleted of this kind of animal. In a few places in the province of Shantung, especially those towns where foreigners are living, the Chinese breed cows for milking purposes, and even the better class natives are taking kindly to the use of milk. It is the fear of typhoid germs in the milk that makes the sale of the tinned variety so large among the foreign population of China. Efforts have been made to introduce German cattle into Tsingtau, but without success. The local cattle are apparently more or less immune from the effects of anthrax and other diseases, as they continue living and thriving even with these diseases prevalent about them. Foreign cattle, on the other hand, die almost immediately. A few years ago the German government brought out a dozen of the finest breeds of German cows, but within two weeks after arrival they had all died. Last year Dr. Martini, a German bacteriologist, for many years chief assistant to Dr. Koch, was sent out to China to investigate the cattle diseases, and to endeavor to eradicate them within the German territory. He has stated that, so far as he can discover, the presence of anthrax has been greatly exaggerated, although other cattle diseases exist. Dr. Martini has reported a most curious fact which has been discovered by him and his assistants as to the precentage of butter fat contained in the milk of the Chinese cows. These locally grown animals are much smaller than the European or American cows, and give a much smaller quantity of milk, but it contains 7 to 8 per cent fat, while cow's milk in the United States seldom yields more than 2 to 3 per cent fat, and 4 per cent is considered extraordinary. This increased percentage of fat is said to be due to the bean cake given to the animals in China. Peanuts and beans are grown throughout the province of Shantung in large quantities, and crushed into peanut oil and bean oil, which are exported to a very considerable extent. The refuse from the

mills is pressed into round cakes, measuring about eighteen inches in diameter and two to three inches thick, which are largely exported to Japan for use as a fertilizer, and also given to cattle as food. The bean cake when used is pounded in rough granite mortars and mixed with the animals' food, and all domestic animals in China seem to appreciate its peculiar flavor. The large percentage of fat contained in the milk in China makes it unsatisfactory for drinking purposes, especially for children, but it produces excellent butter in large quantities, there being very little waste material, and it is so easily made that merely shaking the milk in a stoppered bottle for a few minutes is said to be sufficient to produce butter.—Journal of the Society of Arts.

URANIUM AND GEOLOGY.*

THE SIGNIFICANCE OF RADIO-ACTIVE MATERIALS IN THE EARTH'S CRUST.

BY PROF. JOHN JOLY, M.A., D.SC., F.R.S.

IN our day but little time elapses between the discovery and its application. Our starting-point is as recent as the year 1903, when Paul Curie and Laborde showed experimentally that radium steadily maintains its temperature above its surroundings. As in the case of many other momentous discoveries, prediction and even calculation had preceded it. Rutherford and McClung, two years before the date of the experiment, had calculated the heat equivalent of the ionization effected by uranium, radium, and thorium. Even at this date (1903) there was much to go upon, and ideas as to the cosmic influence of radio-activity were not slow in spreading.

But few have seen a thermometer rising under the influence of a few centigrammes of a radium salt; but for those who pay due respect to the principles of thermodynamics, the mere fact that at any moment the gold leaves of the electroscope may be set in motion by a trace of radium, or, better still, the perpetual motion of Strutt's "radium clock," is all that is required as demonstration of the ceaseless outflow of energy attending the events proceeding within the atomic systems.

Although the term "ceaseless" is justified in comparison with our own span of existence, the radium clock will in point of fact run down, and the heat outflow gradually diminish. Next year there will be less energy forthcoming to drive the clock, and less heat given off by the radium by about the one three-thousandth part of what now is evolved. As geologists accustomed to deal with millions of years, we must conclude that these actions, so far from being ceaseless, are ephemeral indeed, and that if importance is to be ascribed to radium as a geological agent, we must seek to find if the radium now perishing off the earth is not made good by some more enduringly active substance.

That uranium is the primary source of supply cannot be regarded as a matter of inference only. The recent discovery of ionium by Boltwood serves to link uranium and radium, and explains why it was that those who sought for radium as the immediate offspring of uranium found the latter apparently unproductive, the actual relation of uranium to radium being that of grandparent. But even were we without this connected knowledge, the fact of the invariable occurrence in nature of these elements, not only in association but in a quantitative relationship, can be explained only on a genetic connection between the two. This evidence, mainly due to the work of Boltwood, when examined in detail, becomes overwhelmingly convincing.

Thus it is to uranium that we look for the continuance of the supplies of radium. In it we find an all but eternal source. The fraction of this substance which decays each year, or, rather, is transformed to a lower atomic weight, is measured in tens of thousands of millionths; so that the uranium of the earth one hundred million years ago was hardly more than 1 per cent greater in mass than it is to-day.

As radio-active investigations became more refined and extended, it was discovered that radium was widely diffused over the earth. The emanation of it was obtained from the atmosphere, from the soil, from caves. It was extracted from well waters. Radium was found in brick-earths, and everywhere in rocks containing the least trace of demonstrable uranium, and Rutherford calculated that a quantity of radium so minute as 4.6×10^{-14} grammes per gramme of the earth's mass would compensate for all the heat now passing out through its surface as determined by the average temperature gradients. In 1906 the Hon. R. J. Strutt, to whom geology owes so much, not only here but in other lines of advance, was able to announce, from a systematic examination of rocks and minerals from various parts of the world, that the average quantity of radium per gramme was many times in excess of what Rutherford estimated as adequate to account for terrestrial heat-loss. The only inference possible was that the surface radium was not an indication of what was distributed throughout the mass of the earth, and, as you all know, Strutt suggested a world deriving its internal temperature from a radium jacket some 45 miles in thickness, the interior being free from radium.

My own experimental work, begun in 1904, was laid aside until after Mr. Strutt's paper had appeared, and a valued correspondence with its distinguished author was permitted to me. This address will be concerned with the application of my results to questions of geological dynamics.

Did space permit I would, indeed, like to dwell for a little on the practical aspect of measurements as yet so little used or understood; for the difficulties to be overcome are considerable, and the precautions to be taken many. The quantities dealt with are astoundingly minute, and to extract with completeness a total of a few billionths of a cubic millimeter of the radio-active gas—the emanation—from perhaps half a liter or more of a solution rich in dissolved substances cannot be regarded as an operation exempt from possibility of error and errors of deficiency are accordingly frequently met with.

Special difficulties, too, arise when dealing with certain classes of rocks. For in some rocks the radium is not uniformly diffused, but is concentrated in radio-active substances. We are in these cases assailed with all the troubles which beset the assayer of gold who is at a loss to determine the average yield of a rock wherein the ore is sporadically distributed. In the case of radium determinations this difficulty may be so much more intensified as the isolated quantities involved are the more minute and yet the more potent to affect the result of any one experiment. There is here a source of discrepancy in successive experiments upon those rocks in which, from metamorphic or other actions, a segregation of the uranium has taken place. With such rocks the divergences between successive results are often considerable, and only by multiplying the number of experiments can we hope to obtain fair indications of the average radio-activity. It is noteworthy that these variations do not, so far as my observations extend, present themselves when we deal with a recent marine sediment or with certain unaltered deposits wherein there has been no readjustment of the original fine state of subdivision, and even distribution, which attended the precipitation of the uranium in the process of sedimentation.

But the difficulties attending the estimation of radium in rocks and other materials leave still a large balance of certainty—so far as the word is allowable when applied to the ever-widening views of science—upon which to base our deductions. The emanation of radium is most characteristic in behavior; knowledge of its peculiarities enables us to distinguish its presence in the electroscope not only from the emanation of other radio-active elements, but from any accidental leakage of inductive disturbance of the instrument. The method of measurement is purely comparative. The cardinal facts upon the strength of which we associate radium with geological dynamics, its development of heat and its association with uranium, are founded in the first case directly on observation, and, in the second, on evidence so strong as to be equally convincing. Recent work on the question of the influence of conditions of extreme pressures and temperatures on the radio-active properties of radium appear to show that, as would be anticipated, the effect is small, if indeed existent. As observed by Makower and Rutherford, the small diminution noticed under very extreme conditions in the γ radiation possibly admits of explanation on indirect effects. These observations appear to leave us a free hand as regards radio-thermal effects unless when we pursue speculations into the remoter depths of the earth, and even there while they remain as a reservation, they by no means forbid us to go on.

The precise quantity of heat to which radium gives rise, or, rather, which its presence entails, cannot be said to be known to within a small percentage, for the thermal equivalent of the radio-active energy of uranium, actinium, and ionium, and of those members of the radium family which are slow in changing, has not been measured directly. Prof. Rutherford has supplied me, however, with the calculated amount of the aggregate heat energy liberated per second by all these bodies. In the applications to which I shall presently have to refer I take his estimate of 5.6×10^{-3} calories per second as the constant of heat-production attending the presence of one gramme of elemental radium.

To these words of introduction I have to add the remark, perhaps obvious, that the full and ultimate analysis of the many geological questions arising out of the presence of radium in the earth's surface materials will require to be founded upon a broader basis than is afforded by even a few hundred experiments. The whole sequence of sediments has to be systematically examined; the various classes of igneous material, more especially the successive ejecta of volcanoes, fully investigated. The conditions of entry of uranium into the oceanic deposits have to be studied, and observations on sea-water and deep-sea sediments multiplied. All this work is for the future; as yet but little has been accomplished.

* Abstract of a paper read before the British Association for the Advancement of Science.

THE WORLD'S PRODUCTION OF COAL.

E. W. PARKER, the coal expert and chief statistician of the United States Geological Survey, estimates the world's production of coal for 1907 at 1,209,184,109 net tons, of which the United States furnished 39.7 per cent. The following table, showing the production of the principal coal-producing countries for the year nearest the one under review for which figures could be obtained, gives the details of his estimate:

	Net tons.
United States (1907)	480,363,424
Great Britain (1907)	299,970,677
Germany (1907)	226,773,605
Austria-Hungary (1907)	43,955,315
France (1907)	40,708,215
Belgium (1907)	26,261,745
Russia and Finland (1906)	23,857,961
Japan (1906)	15,362,467
India (1906)	10,957,240
Canada (1907)	10,510,961
New South Wales (1906)	8,541,525
Spain (1906)	3,620,588
Transvaal (1907)	3,261,533
New Zealand (1906)	1,937,080
Natal (1905)	1,264,995
Mexico (1906)	846,416
Queensland (1907)	765,265
Holland (1906)	587,283
Italy (1906)	521,711
Sweden (1906)	327,361
Victoria (1906)	179,907
Cape Colony (1906)	142,877
Tasmania (1907)	65,958
Other countries	8,400,000
Total	1,209,184,109

It will be observed that in 1907 the United States produced 60 per cent more coal than Great Britain, and over 100 per cent more than Germany. Exclusive of Great Britain, the United States produced in 1907 more coal than all the other countries of the world combined. Since 1899 this country has held first place among the coal producers. It has so far outdistanced Great Britain that that country can no longer be considered a rival, although it is only nine years since it was supplanted by the United States as the greatest coal-producing country of the world. It may also be noted that more than 98 per cent of the total world's production of coal is from countries north of the Equator, the countries south of that line producing less than 20,000,000 tons annually.

COST OF CONCRETE FLOORING.

THE cost of concrete flooring is concisely placed as follows by an exchange in answer to a question relating to the basement and first floors of a school house with 4,000 feet of floor. With cement at $2 per barrel and sand gravel at $1.50 per cubic yard, a 4-inch basement floor will cost about 14 cents per square foot. The first floor will require forms and reinforcing, and its thickness will depend on distance between supports. With supports 12 feet apart, the floor would cost 32 cents per square foot, if 20 feet apart about 50 cents per square foot. These figures are approximate.

Correspondence.

A CORRECTION.

To the Editor of the SCIENTIFIC AMERICAN:

Will you permit me to point out that an error has been made on page 231 of your current SUPPLEMENT in crediting an article on "Industrial Dust and Disease" to our contemporary Engineering. The article appeared in the Engineer of September 4, page 239. It may be of some convenience to your readers if you correct this little slip.

THE EDITOR OF THE ENGINEER.

London, England, October 19, 1908.

HOW WE DISCOVERED EROS.

By FELIX LINKE.

THE night of August 13-14, 1898, was an important date in the history of astronomy. In that night, nearly a hundred years after the discovery of the first asteroid (in the first night of the nineteenth century) Dr. Gustav Witt, then director of the Urania Observatory in Berlin, with the assistance of the writer, discovered the little planet Eros, which possesses a unique importance for astronomers.

The paths of the asteroids lie between the orbits of Mars and Jupiter, which are so distant from each other that the existence of an intermediate planet had long been suspected, and such a planet was also required to complete the series of the planets, in accordance with the law of Bode and Titius. All attempts to fill this gap failed until January 1, 1801, when Piazzi discovered the small planet Ceres, the orbit of which was computed by Gauss, and found to lie between the orbits of Mars and Jupiter. Within a few years three other asteroids, Pallas, Juno, and Vesta, were discovered and 323 of these minor planets were known in 1891. Then Dr. Max Wolf commenced a systematic search for asteroids by a photographic method, based on their motion relative to the stars. In a photograph made with an equatorial telescope and a long exposure the fixed stars appear as points, amid which the image of an asteroid or other planet is conspicuous as a short line. This method, though not free from practical difficulties, proved very fruitful. Wolf discovered more than a hundred asteroids by its aid and Charlois also employed it very successfully.

A few years later Dr. Witt adopted the photographic method. In 1896 he discovered an asteroid which he named Berolina in honor of the city of Berlin, and in 1898 he made a second discovery which is more important than those of all the asteroids. He and I made photographs nearly every night in August, doing all the work ourselves. On the night of August 13-14 we made a special photographic search for the asteroid Eunike, or No. 185, which had not been observed since 1889 and which should be found, according to its computed orbit, in the vicinity of the star Beta, in Aquarius. The plate was exposed nearly two hours and was immediately developed, in accordance with our custom, so that in the morning it was dry and ready for examination. We found the traces of Eunike and another known asteroid, Althæa, but we also found a third faint and indistinct trace, apparently made by a body in very rapid motion, for the length of the mark was about 0.016 inch, twice the length of the other traces. At first we thought that we had discovered a comet. On the following night the great refractor of the observatory was directed to the spot and a star-like object of the tenth or eleventh magnitude was revealed. The reduction of the observations showed an apparent motion much more rapid than that of any known asteroid, but, as the object was evidently not a comet, it was classed as an asteroid. Its remarkable speed caused it to be studied by many astronomers and within a short time numerous observations were available for the determination of the orbit. The calculation resulted in the surprising discovery that the new planet could not be a member of the known group of asteroids, as its orbit lay almost entirely inside the orbit of Mars. Eros approaches the earth more closely than any other body except the moon. It is a remarkable circumstance that it was discovered when it was near its aphelion and consequently in conditions very unfavorable for observation. A few years earlier it must have been very near the earth and visible to the naked eye but, apparently, nobody saw it. After the orbit had been determined its traces were found on photographs of that period, but it had never been recognized as a planet.

Chance played a part in our discovery. Prof. Charlois, in Nice, photographed the same region on the same night but did not develop his plate at once. When the news of our discovery reached him he developed the plate and found the trace of Eros. Dr. Witt's good fortune is the more remarkable as we were working with very crude apparatus. Our photographic telescope was made up of parts of several instruments, roughly patched together. The cross-wires were illuminated by a small electric bulb, inclosed in a box which was made of pieces of cigar boxes, and was tied to the tube with string. At first the box was covered with a cloth cap, belonging to another instrument, in order to protect our eyes from the heat and light of the lamp, but one night this cap caught fire and thereafter we got along without it. The driving clock, which should have compensated the earth's rotation and kept the telescope directed to the same point of the sky, was a masterpiece, for it defied mastery by the most skillful mechanics. Only the habit of years enabled it to turn the telescope at all, at least in the positions in which we commonly used it, and it did not run correctly for five seconds at a time, so that it was scarcely safe to remove the eye from the telescope or the hand from the regulating wheel during the exposure, which was never shorter than two hours! Dr. Witt gave an amusing description of our difficulties at a meeting of astronomers at the observatory in the following winter, when the new planet Eros was christened with a "Salamander," according to good old academic custom.

The importance of Eros to astronomy is due to its smallness and its close approximation to the earth at certain epochs. It is too small to be measured directly, but its diameter is inferred from photometric measurements to be about 10 miles. Yet great hopes have been founded on this tiny planet. At times Eros comes so near to the earth that its distance can be measured with very great accuracy, and from the distance thus obtained the distance of the sun and all the dimensions of the solar system can be determined with greater exactness than is attainable by any other method. In 1892, before we knew of the little planet's existence, it must have come within 15 million miles of us. The next near approach will occur in 1931, when the distance between Eros and the earth will be less than 13½ million miles—about half the distance of Venus, when in transit over the sun's disk. Observations of transits of Venus have been mainly relied on for the determination of the earth's distance from the sun, which is the unit of astronomical measurement, but there will be no transit of Venus until 2004—and then it may rain!

Eros exhibited remarkable fluctuations in luminosity during its fairly close approximation to the earth in the winter of 1900-1901. These variations gave rise to the most diverse conjectures concerning the physical condition of the little planet. Some astronomers pictured it as a double or binary planet, analogous to the binary stars, others gave it an irregular form, the different parts of which would reflect the sun's light unequally, etc. The peculiar phenomenon gradually disappeared and its cause remains a mystery.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Gartenlaube.

THE TURNOVER FILTER.

CONSUL MAXWELL BLAKE, of Dunfermline, furnishes the following information concerning a new mechanical filter for the cleansing of filtering beds in the purification of water, which is being adopted in Scotland:

The discoveries of bacteriology have long emphasized the hygienic importance of uncontaminated water for purposes of domestic consumption, and with the increase in population and the growth of manufacturing open water beds have become so liable to pollution from effluents, waste products, emulsified oils, and other collective impurities, that softening processes and mechanical filtration have now become necessary for the various requirements of industrial activity.

Bleachers and dyers, textile factories, paper makers, and manufacturers generally, who rely upon feed water for boiler supply, evince an increasing interest in the subject of mechanical filtration, as is indicated by the large number of automatic filters at present on the market.

Hitherto the principal difficulty experienced with mechanical or rapid filters has been the more or less imperfect methods of cleansing the filtering bed. Various washing arrangements have been devised for this purpose, such as the injection from the bottom of streams of cleansing water at high pressure, and revolving arms and rakes. None of these, however, is said to have given complete satisfaction, as that part of the filter bed beneath the nozzles (introduced to conduct the reverse flow of water) is frequently undisturbed, and often the rakes and arms do not effectively remove all coagulated masses adhering to the sides of the filter lying between their operating paths.

It is claimed that these objections have now been overcome by the new turnover pattern of filter, one of which has been installed in a local linen factory. This filter is spherical in construction, and, as its name implies, is cleansed by a rotating process, during which the filtering bed of fine indestructible quartz is completely reversed with each revolution of the filter. The scouring action, accompanying the shifting of the quartz, is claimed to be a distinct merit, as it is said to effectively remove all adhering matter from the inside of the filtering receptacle, at the same time throwing to the surface a new portion of the filtering body.

Other concomitant advantages of the turnover system are said to be: The expense of erecting elevated reservoir tanks to supply cleansing water under pressure is avoided; low-priced centrifugal pumps operating at low heads can be substituted in conjunction with the turnover filter for more expensive machines; the filtering chamber can be examined at will without removing the filtering material by a simple revolution of the chamber; large types of filters, with a capacity up to 30,000 gallons per hour, clean as easily as the smaller types.

All the operating gear is outside the filter, and is easily visible. These filters are generally constructed of cast iron in preference to steel plates.

The simple turnover filters are used for filtering out ordinary suspended matter without any chemical treatment; they are also used as roughing filters for town water supplies. In cases where the bacteria in raw water number about 1,000, they have been reduced to 20 per cent without chemical treatment. Special chemical-treating plants in conjunction with the turnover filter are also supplied.

THE CAT AND THE PLAGUE.

DURING the past plague season in India there have been epidemics of plague in fifty-four towns and villages in Amroati district, and investigations have been made in nearly all of these to find how far the presence or absence of the disease could be accounted for by the absence or presence of cats. The reports were too numerous and too voluminous for inclusion in a short paper, but it was, says Lieut.-Col. Buchanan, of the Indian medical service in the British army, "perfectly clear from a perusal of them that the keeping of cats is *the* method of preventing plague." To all other methods, in his opinion, there are objections more or less grave, but to the keeping of cats there are next to none. Hindus object to killing rats because the rat is the *sowari* (means of locomotion) of their god Gunpati. Some of them even catch rats in order to let them go free in the fields. Jains, it is true, object to cats, but in small towns they are few in number and in villages they are rarely to be found. In Saur plague was severe among the Bhowani Dhers, but the Mallies, who keep buffaloes and consequently cats, which are attracted by the milk, escaped completely. The Dher is not allowed to keep cats because when a cat has kittens or dies in his house he is put out of caste. Some Dhers living in wattle huts escape the plague entirely. This at first puzzled Col. Buchanan until he found that rats do not harbor in that kind of structure. Other Dhers living in mud huts were severely visited by the plague.

So greatly was the Dher community impressed by these facts that now many of them keep male cats, thus avoiding the caste penalty so far as the birth of kittens is concerned. "It is a great pity," continues Col. Buchanan, "that the members of the recent Plague Commission did not make some experiments on the cat as a rat-destroyer. Neither the members of the Plague Commission nor Prof. Haffkine in his recent lecture on the 'Present Methods of Combating Plague,' have, as far as I have seen, said a word about the cat. One member of the commission gives a whole page of figures to show that, in spite of vigorous efforts for a whole year, the number of rats could not be considerably reduced by traps. He does not tell us whether there was one trap or fifty, but I can assure him that his whole argument would be completely upset if a few cats were introduced." Col. Buchanan looks upon rat destruction and inoculation as temporary expedients capable in certain circumstances of yielding useful results, but both in the main hurtful because they distract attention from the only true remedy. "The more attention we give to inoculation," he says in conclusion, "the less we are certain to give to the only sound common-sense method of preventing plague, viz., the keeping of the natural enemy of the animal that is responsible for spreading the disease."—Indian Medical Gazette.

A Recent Patented Method of Producing Celluloid.—I. In place of the camphor, naphthaline is used, and we obtain thereby a cheaper and less inflammable celluloid. The new mixture is made from 100 parts of nitrocellulose, 60 parts of alcohol, 30 parts of acetone, and 10 parts of naphthaline. To increase its flexibility, castor oil is also added. The unpleasant naphthaline odor disappears when the naphthaline celluloid is kept a long time in the air. II. As the naphthaline, on account of its strong odor, is likely to be more disagreeable than camphor, in place of it nitronaphthaline is used, best of all in the following quantitative proportions: 1,000 parts nitrocellulose, 418 parts camphor, 210 parts nitronaphthaline, 350 parts of alcohol, and 172 parts of benzine. According to Pleissety's English patent, celluloid is made non-inflammable by the addition of chloride of aluminium or nitrate of aluminium.

SCIENCE NOTES.

From analyses made by W. C. Ebaugh and Kenneth Williams we know that the water of Great Salt Lake has varied widely in composition during the last twenty years, as indicated by the following partial results:

Year.	Density at 15 Deg. C.	Per Cent by Weight, Total Solids.
1885	1.1225	16.716
1903	1.2206	27.721
1907	1.1810	22.920

The solids contain the following constituents:

	Per Cent by Weight of Sample.	Grammes per Liter.
Chlorine	12.67	149.633
Sulphate radical	1.53	18.069
Sodium	7.58	89.520
Potassium	0.72	8.503
Magnesium	0.45	5.314
Calcium	0.04	0.508
Total solids (direct determination)	22.92	270.675

Since a potential of some 100,000 volts exists a mile above the earth's surface, it has been argued that a balloon must assume an enormous charge, which on landing might become dangerous. In reality, balloons are sufficiently conducting to adapt themselves to the varying potential of the medium. Their conductivity may be increased by painting them with chloride of lime, but this becomes ineffective after about an hour's sunshine. But the real danger lies not in the charge of the balloon as a whole, but in the different charges of its parts. These are sometimes greatly increased by the friction of the sand from the ballast against the car. A single bag may give rise to dangerous charges. The moment of landing is particularly dangerous, and the slitting of the envelope usually shows sparking in the dusk. These sparks are not dangerous unless a certain minimum capacity is discharged by them. The valve, having been insulated on the top of the envelope, must be carefully and gradually discharged on landing.

Among the very common trees, yet almost totally unknown, is the much despised, ill-smelling ailanthus. A million dollars could not buy a board in any lumber yard. The dealer, or manufacturer of lumber, never saw it on sale and would not recognize it if seen. Yet it is a magnificent wood, resembling white ash, and capable of receiving a high polish. The tree is a native of the Molucca Islands, just south of the equator, some four degrees, and not far from Borneo. Here it forms a very large forest tree. It was brought from China during the first decade of the nineteenth century and has gradually spread over the United States, planted for shade only. The male trees are very offensive while in blossom, but the female trees have no such odor. The trees have a tropical appearance, spread by underground roots, suckering so as to make them a nuisance on the lawn. The ailanthus has run wild in the Cumberland Mountains, groups of the trees being quite frequently found where apparently the birds have taken the clusters of winged seeds for lining their nests, some of the seeds thus escaping them.—Arboriculture.

A British Association paper from the National Physical Laboratory, by Dr. J. A. Harker and Mr. F. P. Sexton, on "The Effects of Pressure on the Boiling Point of Sulphur," is of importance, because that boiling point is the third fixed point on which the temperature scale of the platinum-resistance thermometer, probably the most exact thermometer we possess, is based. That boiling point of sulphur, 445 deg. Cent., Dr. Harker said, was accurately known; but the effect of pressure was disputable. Their new experiments gave the formula $T = T_s + 0.0904\ (p - 760) - 0.0000519\ (p - 760)^2$, where T was the temperature of the vapor on the air scale at pressure p (in millimeters), and T_s the normal boiling point. As the pressure rose to 800 millimeters, the difference $T - T_s$ rose to + 3.53 deg. Cent., and as the pressure fell to 700 millimeters, the $T - T_s$ became — 5.61 deg. Cent. These values were sufficiently greater than those of Regnault to deserve attention. The difference per millimeter of mercury amounted to 0.096 deg. Cent. at 700 millimeters, and decreased steadily to 0.087 deg. at 800 millimeters, changing sign at 760 millimeters; the effect of reduced pressure was much greater than that of increased pressure. In this and other points they agreed with Holborn and Henning (of the Reichsanstalt). They had heated their sulphur in an iron tube, inside which the thermometer tube was fixed; it was essential that the diaphragm should dip quite 3 inches into the molten sulphur, of which they had 5 inches in the tube. Principal E. H. Griffiths, F.R.S., of Cardiff University College, was glad that this important point had at last been settled. It was not unnecessary fuss; for high-temperature research and explosion work that the third fixed point was most essential.

ELECTRICAL NOTES.

A new method of slaughtering cattle painlessly has been devised by Dr. Stephane Leduc, of Nantes, France. A low-voltage direct current, which is given a pulsating flow by means of an interrupter, acts on the animal to suspend circulation and respiration without injuring any of the essential organs. The animal is subjected to this current for a few minutes, when it dies without pain from asphyxia. If subjected to the current for less than two minutes life will be restored and the animal will show no ill effects from its treatment. The muscles are contracted by the current, causing profuse bleeding, and for this reason the meat is said to be of a superior quality.

In a paper on "The Extension of Optical Ideas to the General Electromagnetic Field," Prof. E. T. Whittaker points out that the resolution of a beam of light into two components polarized at right angles to each other led to an expression of the state of the luminiferous ether in terms of two potential functions, one for each of the polarized beams, not only in the case in which the disturbance consisted simply of luminous or electromagnetic waves, but also in the more complicated case, when electrostatic changes and voltaic currents were present. The ether thus appeared to be a medium with two essential qualities, which were both scalar (like the temperature and pressure of a gas), and the various vectors, in terms of which the electromagnetic field was usually specified (e. g., the elastic force and magnetic induction), were really derived from the variations of these two qualities in space and time.

A successful trial of the Rosenberg train-lighting equipment, according to the Electrician, was made recently on the Austro-Hungarian government railways. The car used for the test contained six compartments, each of which was equipped with two 16-candle-power tungsten lamps. The car also carried five other lamps of the same type and rating. The lamps operate at 32 volts, while the generator is designed for an E. M. F. of from 44 to 58 volts, the full-load output being 30 amperes. A storage battery capable of supplying energy to the lamps for six consecutive hours has been installed. Iron resistances of the cartridge type are connected in series with the lamps when they receive energy from the generator. These resistances are mounted in the vestibules. In the vestibules are also fixed field rheostats which serve for adjusting the voltage of the generators when charging the storage battery, and an automatic reverse-current relay which prevents the battery from feeding energy to the generator when the speed is low. It is reported that the lamps give a steady light and do not flicker when the train is accelerating or retarding.

Mr. W. Thomson, F.R.S.E., of the Royal Institution Laboratory, Manchester, has studied "The Reducing Action of Electrolytic Hydrogen on Arsenious and Arsenic Acids when Liberated as Arseniuretted Hydrogen from the Surfaces of Different Elements." The experiments were made in cells containing in a porous pot the cathode of the element in question and outside a platinum anode; the arseniuretted hydrogen evolved was decomposed in the usual manner to produce a mirror of arsenic in graduated glass tubes, and the density of the mirror deposited during the time interval of 2½ minutes indicated the rate of reduction. With different cathodes this rate decreased, for solutions of arsenious acid, in the order: (Lead, zinc, cadmium, tin, and silver), graphite, iron, platinum, aluminium, gold, cobalt, nickel, and palladium, the first five bracketed metals being equally efficient. But this order did not at all hold for solutions of arsenic acid, and the discrepancies could not be explained by the supertension hypothesis, according to which certain metals assume, under certain conditions, potentials higher than they usually take before liberating gases: this is the interesting point.

A subway system is to be established at Berlin for the postal service, using small electric cars for the purpose. As the city service is overcharged by the large amount of mail matter which is carried at present, this measure was taken in order to give the proper facilities for handling the mails, both in the central and branch post offices. The administration has now drawn up a project for constructing two underground lines for mail transportation, and these will be used exclusively for letters. The first of these lines will have the form of a belt line which will pass around the central part of the city and will serve to connect the principal railroad depots. A second subway line is to run directly between the central office and the new post office, also to the Potsdam depot. The tunnels for both these lines are to be run directly underneath the streets and will be of small section, measuring 6 feet wide and 3 feet in height, and will have a double track for the postal cars. Between the two tracks there will be a depression which serves as a footway so as to allow an inspector to pass along the tunnel throughout the whole length. Trains of small cars, which will run upon an automatic system without a motorman, will circulate in the tunnels at a speed of 25 miles an hour. The present system of underground lines is somewhat analogous to the one which is now in use in Chicago in the telephone subways.

ENGINEERING NOTES.

Consul James W. Ragsdale, of St. Petersburg, reports that the Russian Volunteer Fleet has started direct steamship communication between Vladivostok and Chinese and Japanese ports, including Tsuruga, Nagasaki, and Shanghai. Passengers and freight will be transported, the latter including chiefly Siberian butter, Russian raw materials, and tea. In view of the abandonment of sailings to American ports, the former steamers of the Libau-New York line will be used on the line to the Black Sea, where an increase of both passenger and freight traffic is looked for.

A report from St. Petersburg says the Council of the Admiralty, which has been considering the plans of the Italian, Col. Cuniberti, and the Hamburg firm of Blohm and Voss for the new battleships, whose construction was recently voted by the Council of the Empire, decided at its sitting, at which only the technical side of the question was discussed, in favor of the German plans. The proposed battleships will be of 20,000 tons burden, will have a speed of 21¼ knots, and their heavy armament will consist of 12-inch guns. They will each carry 800 men. The vessels will be built at St. Petersburg yards, with Russian material, by Russian workmen.

A discovery which is regarded of far-reaching importance in the aniline dye industry has recently been made by Prof. A. G. Green, who has evolved a new process for the production of an aged aniline black. The process differs entirely from all those at present practised to obtain this color, inasmuch as the oxidation of the aniline is carried out solely or principally by the oxygen of the air. No oxidizing agent is employed to secure this end, so that there is no danger of weakening the fiber. The basis of the method is the discovery that by adding a small quantity of paradiamine or of para-amidophenal to a mixture containing aniline and an oxygen carrier such as salt of copper, the oxidation of the aniline by atmospheric oxygen is considerably accelerated. A prominent feature of the invention is also the fact that a fuller utilization of the aniline becomes possible, unattended by any possibility of spontaneous inflammation, with a corresponding diminution of injury to the operatives, while the manufacture is simplified and a greater speed of production rendered possible.

A novel system of breakwater construction is being used in the harbor improvements at Algoma, Wis., and is described in the Engineering News. The system consists essentially in the use of large boxes or caissons of reinforced concrete, forming sections of the breakwater. These are built on shore, launched like vessels, towed into place, sunk by means of water ballast, permanently filled with stone, and finally covered with a concrete deck or superstructure. This system of construction for breakwaters, piers and similar structures is the invention of Major W. V. Judson, Corps of Engineers, U. S. Army, and a patent was granted to him on March 19, 1901. Since that date, similar methods have been used in Canada and to some extent abroad. The purpose in this case was to reduce the amount of mass concrete required in the monolithic blocks frequently employed for work of this kind, and to reduce the difficulties of handling and settling these enormous concrete blocks. The caissons were easily placed, and the necessary weight for stability was given by a filling of stone, sand, gravel, or second-class concrete at small cost. The first application of the system in this country, however, has been during the present year on the work at Algoma. Our contemporary states that Major Judson receives no royalty from the United States, having patented his system largely to protect the interests of the government. It will be seen that the system represents a decided departure from ordinary methods, and that it is applicable to various kinds of work.

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